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THE TECH ENGINEERING NEWS

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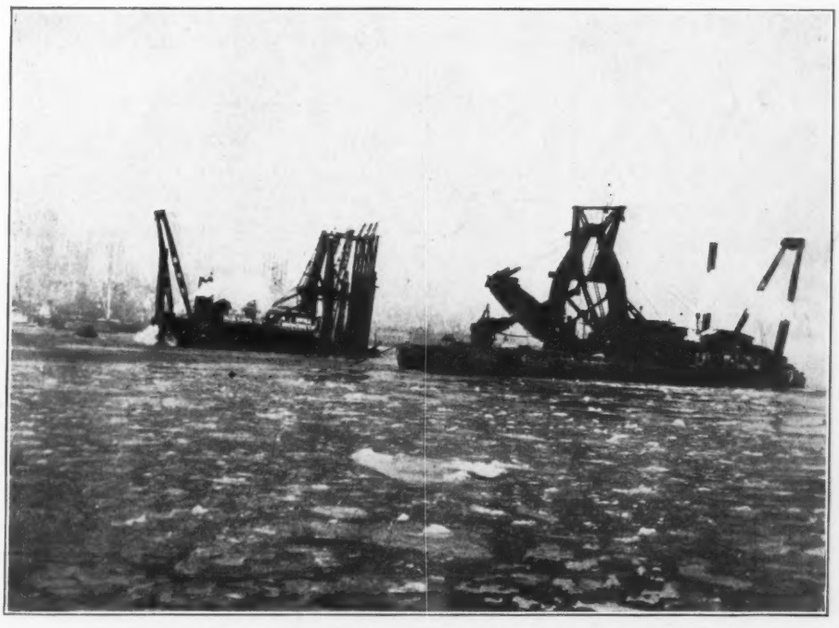

DRILL BOAT AND DREDGE BLASTING HELL GATE CHANNEL
"Engineering and Explosives" (Figure 1. See page 93)

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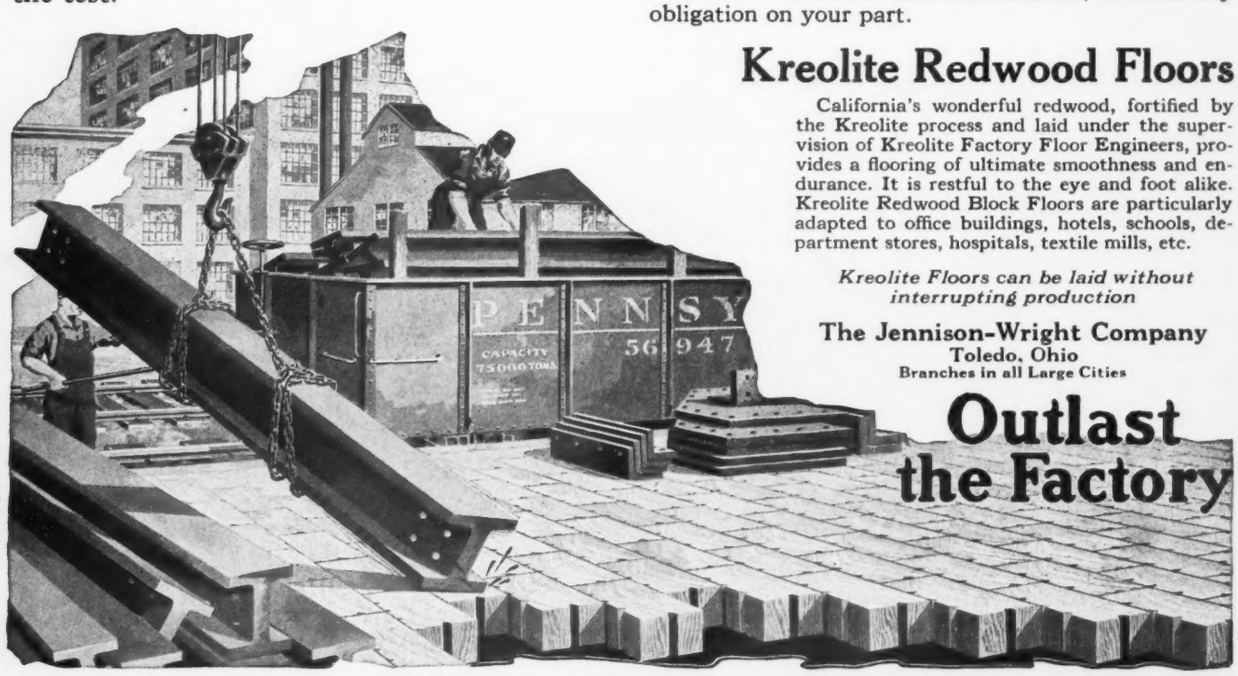

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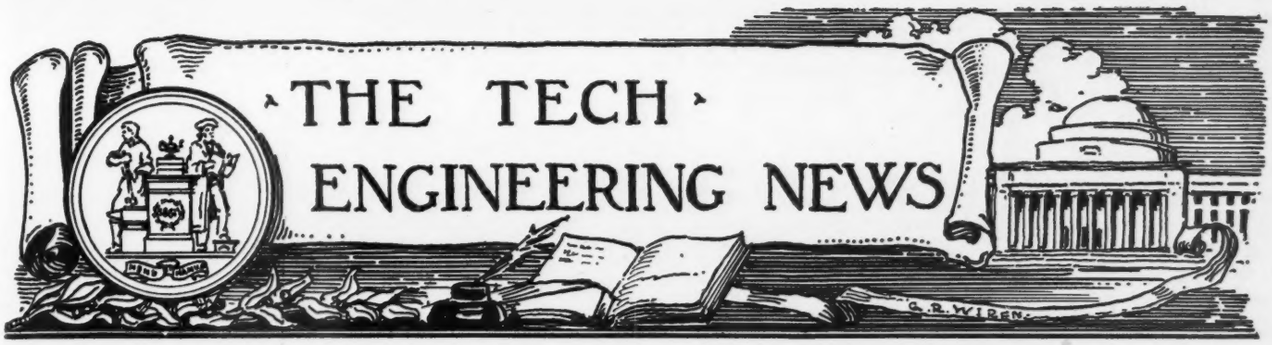
BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES



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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V | OCTOBER, 1924 | NUMBER 3

ENGINEERING AND EXPLOSIVES

By COLONEL WILLIAM C. SPRUANCE

Vice-President, E. I. du Pont de Nemours & Co., Wilmington, Delaware

MODERN engineering practice on major construction projects involves methods and equipment not only undreamed of by our forefathers but often neither understood nor realized by engineers in general.

In these days of specialization, information as to the progress and improvements developed in a given branch of engineering is frequently not available to the engineer engaged in other activities, and to whom the knowledge would be interesting and perhaps of value at some future time.

An engineer who specializes in the use of explosives should be conversant with the principles and methods of the major branches of engineering, but with the exception of the Mining and Civil Engineers, few members of the profession have any adequate conception of the adaptability of modern high explosives to engineering practice.

This article deals with the application of explosives to the Engineer's problems and refers to some of the projects which either could not have been carried out without the aid of dynamite or which would have been impracticable because of the time and expense involved if other known agencies had been employed.

The deepening of the channel through Hell Gate in the East River, New York, which is now in progress, is an interesting example of a project which would be impossible of achievement without the use of modern explosives. This consists of submarine blasting with the removal of the rock at the bottom of the river to deepen the channel to thirty-five feet. When completed it will be possible for merchant vessels and battleships, drawing more than 30 feet, to pass from New York harbor or the Navy Yard through Long Island Sound to the Atlantic Ocean by another route than the old Sandy Hook channel, and it will afford a new inside waterway for ships bound up or down the coast through the East River without going outside around Long Island. For generations Hell Gate has been a menace to navigation. It used to be estimated that out of every fifty sailing vessels trying to pass the channel, one was seriously damaged.

Modern explosives, which can be detonated under water, have solved the problem and we may expect, in our day, to see the entire channel of the East River cleared up. Recently Pot Rock Reef, one of the most serious obstacles to navigation at Hell Gate, has been removed. In such work specially designed rock drills and other novel equipment are used. A drill boat is anchored over the reef and metal pipes are lowered to the rock at distances about ten feet apart. Through these pipes a battery of drills of special heavy construction bores holes to a depth of ten feet. The explosive used is eighty or ninety per cent gelatin dynamite and primers are made with sixty per cent straight dynamite and No. 8 waterproof electric blasting caps. The charge is packed solidly in metal pipes, slightly smaller in diameter than the bore hole, with a wooden plug in the bottom. The drill boat is moved away by means of heavy chains, and when at a safe distance the shot is detonated by electric current. In removing Pot Rock Reef, three holes were shot at a time, resulting in shattering as much as 300 square feet of rock surface.

Among the most recent examples of the great speed obtained by modern explosives may be cited the boring of the Shandaken Tunnel under the Catskill Mountains, this being a part of the development to increase New York City's water supply. This tunnel is 18.2 miles long; the longest ever constructed by the hand of man.

In one year the builders, through the use of powerful explosives, were able to put through nearly nine miles of tunnel excavation. The rock encountered varied from shale through sandstone to true quartzite, the latter

(Continued on page 116)

EXCAVATING A DITCH WITH DYNAMITE

A spectacular ditch blast near Menominee, Michigan, the excavation being a quarter of a mile long, about 4½ feet wide and 3 feet deep. This method leaves no spoil banks on the sides, as is the case when ditches are dug by hand.

THE VACUUM—THERE'S SOMETHING IN IT

By W. R. WHITNEY

Director, Research Laboratory, General Electric Co.

WE humans want better minds, broader horizons and greater understanding. Scientists are at work in their respective fields searching for new truth, to improve the process by which our minds, our horizons, our powers and our outlooks grow.

When, in the middle ages, the great cathedrals of the world were being built, the mentality of men seems to have been directed to systematic subordination of creation rather than to active appreciation of it; to acquiring salvation, or "safety first," rather than knowledge or understanding. Today you scientists, in seeking truth, think of "safety first," last.

We are told that if the total age of mankind be expressed as the life of a man of fifty years, and if he then looks back upon his progress, he will see that what marks his greatest advancement are events occurring in the most recent years. For example, such a 50-year man now sees that he had not learned to scratch the simplest records on stone until his forty-ninth year. All the immense advantages of printing have only existed three months for him. He has only just learned how to pass along what he has learned. The uses of steam, which now seem so necessary, were acquired only three or four years ago. The uses of electricity (street cars, lamps and telephones), which did not actually begin until about 1880, arrived the day before yesterday to this 50-year mankind. The automobile, wireless, X-rays, radium and most of the things which occupy our interests today, were actually discovered on this particular fiftieth birthday.

The power outside of his own muscles, which during the past two or three months, he has learned to control, has grown to nearly twenty horsepower, or one hundred manpower, for every man in the country. Therefore it makes only one per cent difference whether all the men work like horses or not. But *guidance* of power is man work, because there are no machine-mentalities. Almost everything but thinking may be artificially done, but knowledge and understanding must be actively sought and used. Man is the only animal that can do this.

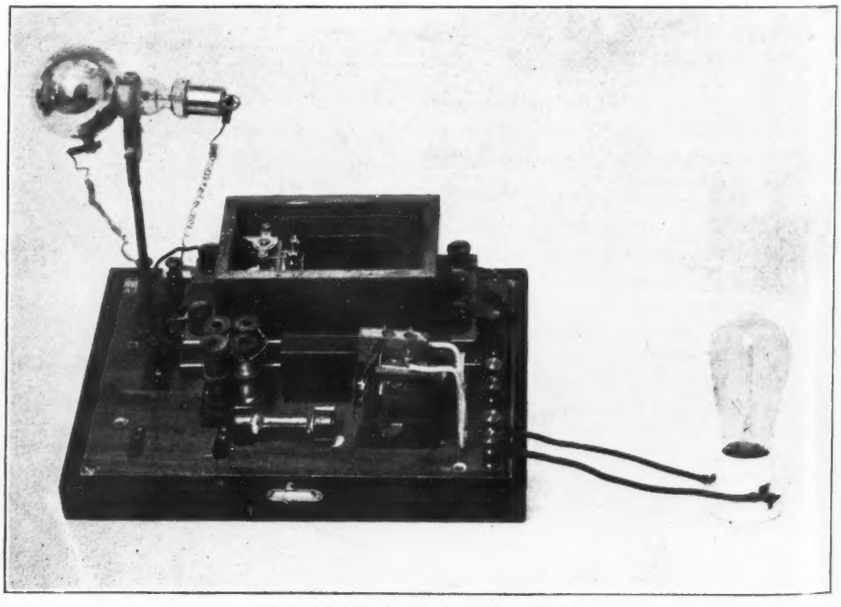
Scientists know that research merely discloses new parts of the infinite unknown. Paradoxically, the enticing, helpful "unknown" increases as men continue to subtract from it. Progress in every line of experimental science follows the same law. The apparently narrow path gradually expands into unlimited, unexplored territory. With his new tools and his increased speed of communication, man finds that he can advance into the unknown faster than his ancestors could, and children seem to learn more rapidly than he did when he was young. The scientists of the twentieth century are legion. But scientists were anathema a short time ago. There is today more chemistry in the atom than there was in all "inorganic" chemistry a few years ago. There is more in the "sugars" now than there was in all "organic" when I studied it. There is more immunity in blood, and more heredity in the microscopic chromosome, than there was in all biology until recently. There is more crystal structure research by X-rays now than research in all mineralogy when Agassiz came to America.

I chose to discuss such a narrow field as the vacuum tube because it seems desirable that the applications of new knowledge be continually distributed throughout the separate sciences. I want to show that in a vacuum, of which one might say "There is nothing in it" (and surely less than in anything else) there is, indeed, an endless amount of interest and utility. The American public now buys over a million dollars worth of glass vacua a week, but that is the least interesting part of the subject.

Everybody pretends to know that "Nature abhors a vacuum." But he who started that tale merely meant that a good vacuum was hard to produce. As probably no one has ever made a vacuum with less gas-molecules in a cubic inch than there are people in the world, we can maintain that perfection in vacua is still precluded by Nature.

My object is to review some studies in vacua so as to create not only the impression that any one may well do research work there, but also certainly anywhere else with pleasure and profit.

We all know that we see at night largely by the aid of vacuum lamps. Through other vacuum lamps, called X-ray tubes, we also see through opaque bodies. The light which illumines our microscope specimen has its analogue in the X-ray light which shows us the crystal structure of matter and the electrical formulae of chemical atoms. Our transcontinental wired telephony is possible through vacuum tubes which, in various forms, also permit our wireless broadcasting and wireless reception from the most remote stations. The workman who keeps his drink hot or cold in a ther-



THE PHOTO ELECTRIC CELL

This apparatus acts in such a way as to cause the lamps shown to light when it is dark and to go out when it is light.

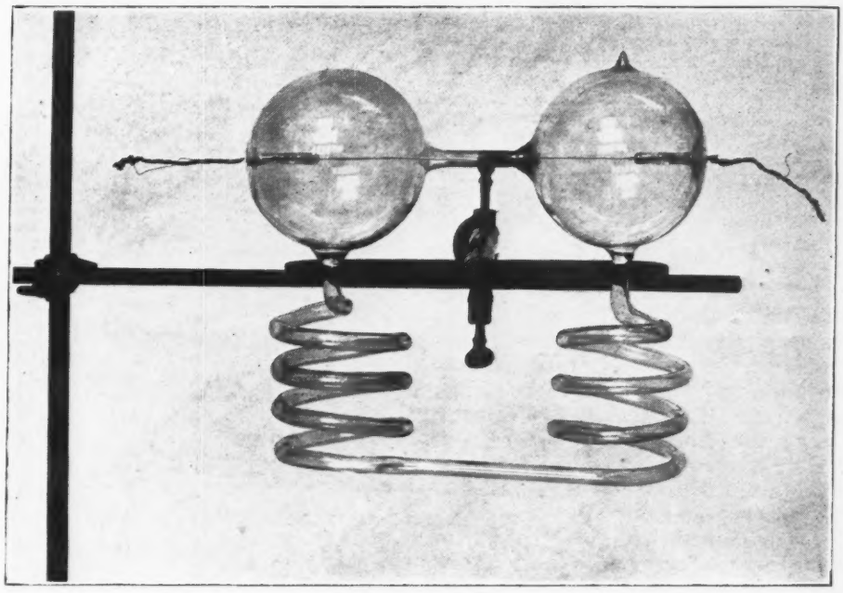
mos bottle is clearly indebted to Sir James Dewar's application of the vacuum, but the scientist is still more indebted to it. All our steam power plants, including turbines, owe their success to vacua.

The latest arrival in the family of the chemical elements (*hafnium*) was discovered by trying it in vacua as an X-ray target. Our list of possible chemical elements was rounded off by Moseley's story of the X-ray spectra just in time to meet the wonderful discoveries of J. J. Thomson and Aston, all made in vacua. The latter showed that most of the elements, supposedly simple, are still mixtures of two or more similar elements (*isotopes*), while Professor Thomson's experiments disclosed by the positive ray method a whole series of new atomic compounds.

While the vacuum was not essential to the work of Milliken in isolation of the electron, yet the earlier work by Thomson and others, and much of the recent work on this ultimate constituent of matter, has been necessarily carried out in vacuum. Today there seems to be no end to the studies which can be based on the fact that an atom or molecule of material may be separated electrically into a positively charged ion (carrying most of the mass) and a negatively charged electron (carrying most of the current).

I may not be sacrificing historical truth too much if I claim that electricity at rest was the first kind known. This may be wrong from many points of view, but I wish to assume it. It then seems logical that electricity in simple direct motion should later appear and that still later we should find various directions and rates of its motion, if it moves at all. It will interrupt this line of argument if we doubt the existence of electricity as a thing, or question the existence of such different kinds of it as static and dynamic. The electricity of rubbed amber was the first and stationary kind (if you will admit that prior to Thales such things as lightning were something else). When the electricity first moved through metals the process was looked upon as a simple directed flow which proceeded until the charged body had delivered its charge.

This direct flow of electricity (a current) was strengthened in its hold on our conception by the great number of different chemical current-producers which followed the controversies between Galvani and Volts a century and a quarter ago. Primary and secondary or storage batteries without number were soon discovered. The current from such batteries was exactly like that which the magneto electric machines produced, when these were developed, after Faraday had shown the effect of moving a wire through a magnetic field.



THE HITTORF TUBE

The direct current of such generating machines was much later followed by the alternated flow, and soon alternating current generators were made for different rates of reversal of direction. Sixty, forty and twenty-five cycle currents are now common and the user takes his choice. These frequencies were once accidents of convenience and economy. For some uses other widely different frequencies of alternation are very desirable, as in wireless, where 100,000 cycles are common.

Now the phenomena which have been found in vacuum tubes promise to give complete control over all these details of kind and frequency of current.

As will be more fully shown later, when a unidirectional current meets vacuum tubes as though it would pass through them, it must find one particular kind of a tube, and the current's direction must be right, because some tubes will let it through only when it is both unidirectional and in the proper direction. These in themselves are rather remarkable things to expect of a vacuum, but as usual, the truth exceeds the expectation.

To give some idea of the extent to which vacuum studies may affect remote fields, let me mention chemical catalysis, the secret of most reactions of life. For example, it is known that mercury vapor in a vacuum, when illumined by light of a certain wave length, will absorb that light and turn the energy over to hydrogen, if hydrogen be present, so that this, in turn, will chemically reduce such substances as cold copper oxide. Here is a new kind of chemical process. It is the kind we have needed in order to begin to explain some of those life reactions which vegetation discloses. That is, similar facts will probably be found to contain the explanation of the catalytic action of sunlight on growing plants.

And so the studies of phenomena in vacua may lead us into the most widely separated fields. The experiments which I have chosen for this evening are illustrations of this fact, and you must not therefore expect them to be very closely related.

I might say, as in our school-day essays, "There are different kinds of vacuum too numerous to mention," and then proceed to mention them all, but I will merely illustrate several cases. A certain kind of vacuum is good enough for incandescent lamps because other factors besides the quality of its vacuum determine the death, or limit the performance of a lamp. But while formerly the incandescent lamp represented the very highest skill then reached in vacuum production, there are now other commercial vacua which are necessarily quite superior. This is true of good thermos bottles, X-ray tubes, radiotrons, and other wireless tubes.

We should first, therefore, give brief consideration to the incandescent lamp, and note a few characteristics. Its low vacuum early disclosed electric cross currents which would not have been found in much higher vacua. Study of these currents has led to the vacuum tubes used in wireless, but also to such

(*Continued on page 112*)

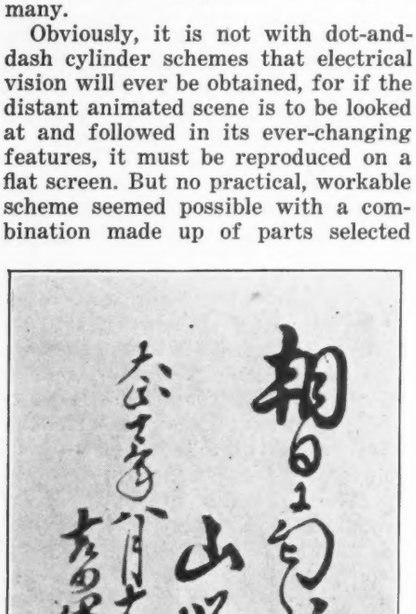
THE TRANSMISSION OF PHOTOGRAPHS BY RADIO

By C. FRANCIS JENKINS
President, Jenkins Laboratories, Washington, D. C.

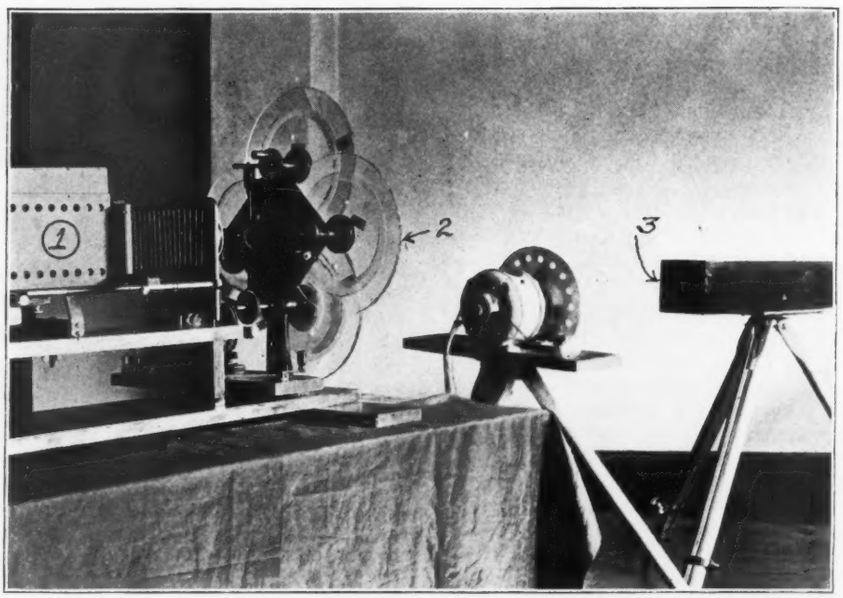
EARLY efforts to serve the eye electrically over a wire, *i.e.*, "television," were coincident with the first efforts to serve the ear, but the "telephone" got the start and attracted to its development most of the electrical talent of the time. About the only remaining activities were devoted to the transmission of pictures by wire, and these have continued to this very day, the latest newcomer being the American Telephone and Telegraph Company, with old apparatus refined and assembled by a corps of their engineers.

With a single exception, the subject of this paper, every scheme which has attained any considerable degree of success has depended upon the synchronous rotation of two cylinders, one at the sending station with the picture which is to be sent; and the other at the receiving station where the picture is to be received. The machines look not unlike the old wax cylinder phonographs. Perhaps the very age of this scheme and because there are no patents to prevent anyone from using it, explains the reason it has been employed so often by so many.

Obviously, it is not with dot-and-dash cylinder schemes that electrical vision will ever be obtained, for if the distant animated scene is to be looked at and followed in its ever-changing features, it must be reproduced on a flat screen. But no practical, workable scheme seemed possible with a combination made up of parts selected from apparatus already employed in science and industry; it was necessary to find a missing part to tie them together.



FIRST MESSAGE IN JAPANESE CHARACTERS SENT BY RADIO



RADIO PHOTO-SENDING MACHINE

(1) lamp house to the left (for illuminating the picture); (2) four Prismatic Rings for moving the picture over the (3) light sensitive cell in the box at the right; time for each picture three minutes; distance limited only by power of the broadcasting station.

Attention was given to the discovery of this missing link, the something which would remove existing limitations. This resulted in the invention of the Prismatic Ring, a new optical shape in glass, acceptable examples of which have been attained only since the perfection of automatic machinery for its making.

In rotation these rings give to a beam of light passing through them a fixed axis on one side of the prism and an oscillating axis on the other side.* These prismatic rings in rotation are comparable to a solid glass prism which changes the angle between its sides, and have a like action on a beam of light passing through them.

The light beam passing through these rotating peripheral rings always oscillates in the diameter of the ring. Therefore, light passing through two rings overlapping with diameters at right angles, will have neither a horizontal nor a vertical, but instead, a resultant oscillation. If one ring rotates many times oftener than the other there will be many slightly diagonal, adjacent, parallel lines covering a given surface on which the oscillating point of light impinges. As the ring-like prism is ground into one face of a plate glass disc, they are referred to in the laboratory as "prismatic plates."

At school one learned that moving a point makes a line, and moving a line laterally develops a surface. It is no trouble to move the point to make a line, but in practice moving the line laterally is not so simple. It is easy enough, however, to make a succession of parallel lines to cover the surface, and this surface may be the picture surface. That was the starting point.

The apparatus for sending a photograph by radio consists of a magic lantern projecting the picture, either a transparent or an opaque picture, say, four inches square. Immediately in front of the objective are two (or two pair) of prismatic plates, one of which makes four hundred revolutions for each single revolution of the other. At some distance in front of the lantern a light-sensitive cell is located. The repeated rotation of one of the plates, the "fast" plate, causes the projected picture to sweep across the

(*Continued on page 110*)

* Note. Described in detail in the Transactions of the Society of Motion Picture Engineers, Montreal Meeting, May, 1920.

FLAT GLASS

By ARTHUR E. FOWLE

Vice-President and Treasurer The Libbey-Owens Sheet Glass Co., Toledo, Ohio

FLAT glass in some form has existed from the earliest times. Only in the last few centuries, however, has it been manufactured in sufficient quantities and at a cost low enough to make it available for general use.

It is interesting to note that the term "flat glass" until very recent years has been a misnomer. All of this so-called flat glass for use in windows and for similar purposes, with the exception of plate glass, which does not come within the province of our story, was slightly "bowed." It was not until an entirely new process of manufacture was perfected that absolutely flat glass was made available to the world.

Glass bottles, jars and vases, since the time of the earliest records, have been a very important commodity of commerce, and at first thought it might seem that the production of these various-shaped glass articles of ancient origin, which are seen in our museums, was more difficult than the production of the common glass window as we know it today; but this is not the case.

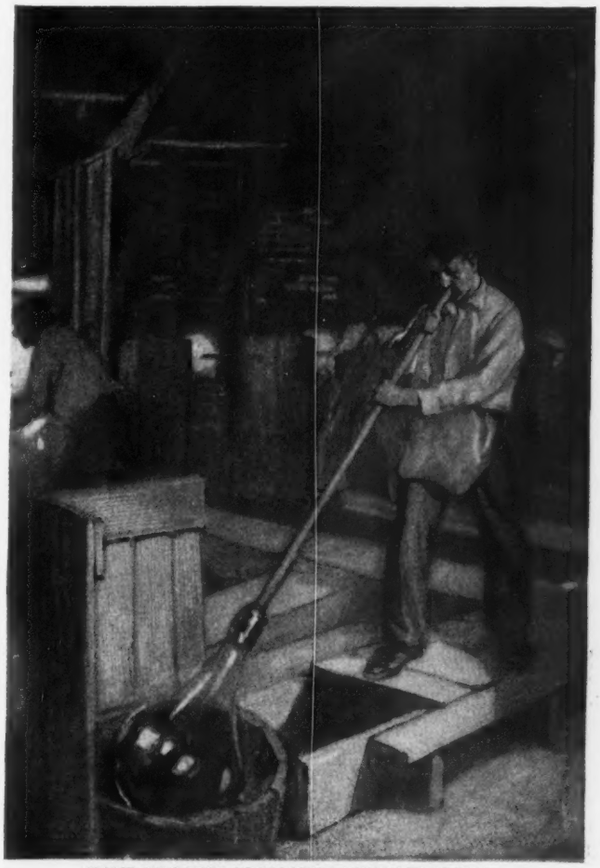
The fact is that the quality of the metal itself entering into common window glass must obviously be far superior in clearness and strength to the metal used for ordinary "blown ware." At the same time the mechanical difficulties entering into the production of flat glass are far greater.

Hence it is not to be wondered at that the world was obliged to wait patiently for centuries for the flat glass which today is so indispensable to human living.

Glass was used most extensively by the Romans and its adaptation to windows was just beginning when Roman civilization was overwhelmed by the northern barbarians. Glass was largely used by the Romans in pavements and in thin plates as a coating for walls. It was used to some extent in windows, but mica, alabaster and shells were more widely employed.

Such glass as was used for windows was very thick and was available only in small pieces. The ruins of Pompeii reveal that glass half an inch thick was used in the windows of the famous baths. Other traces of Roman glass have been found in Roman ruins at London. Most of the pieces had evidently been made by casting, and the discovery of sheet glass at Silchester shows that this process of making glass was known at that time.

The first mention of the use of glazed windows in Great Britain was in the seventh century when Benedict of Wearmouth sent to France for workmen to glaze a church.



HAND PROCESS OF MAKING WINDOW GLASS: BLOWING THE BALL

The use of stained glass in small pieces for leaded windows was characteristic of the Gothic cathedrals in the twelfth and thirteenth centuries. The old masters who mixed the colors for the variety of shades required in this wonderful art of the medieval stained glass windows attained a degree of skill that appears to have died with them, for we are forced to admit that our modern artisans cannot produce the depths of color and variety of shades attained in those times. This is especially true of the deep blues and purples found today in so many of the old world cathedrals and churches.

When Edward I brought back his bride from Spain, his father, Henry III, was so delighted with little Eleanor, then in her teens, that he made the youthful couple a present of a house furnished with glazed windows, special mention in the narrative of the day being made of the glazing of the windows.

In the reign of Elizabeth, the Duke of Northumberland, on leaving his estate, was warned by his steward that he had better order the windows taken out of his house and stored in safe keeping until his return—a significant illustration of the value and importance of a few glass windows even in the grandest habitations of that day. Even the luxury-loving Charles II (1660-1685) had no glazed windows in his palace.

At the close of the eighteenth century, shortly after the Revolutionary War, there existed in Paris, the world's most civilized capital, a large corporation engaged in the manufacture of window sashes fitted with oil paper.

Both France and Belgium reverted to this expedient for enclosing their houses during the first days of reconstruction after the close of the World War—all of the window glass factories being destroyed or unable to resume operations.

Development of flat glass was slow in the New World as well as in the Old, until the modern era of industry arrived. Probably the first attempt to manufacture window glass in the United States was in Allowaystown, New Jersey, in 1738. This venture was unsuccessful, as was a later attempt by Robert Hewes, who, in 1790, started a small window glass factory in a forest near Concord, New Hampshire. A few years later, in 1797, Gallatin and Company started a window glass factory in New Geneva, Pennsylvania, ninety miles south of Pittsburgh. This factory proved fairly profitable, the glass at that time selling for $7 per box of fifty feet, 10 inches by 10 inches in size.

The use of coal as fuel in glass-

Editor's Note: This subject is more fully discussed in Mr. Fowle's book. "Flat Glass," Evans-Winter-Hebb, Detroit.

making brought a decided change. Previously the industry had been a wandering one, moving from place to place as the need for fresh fuel arose. The use of coal made possible steady development at one place.

O'Hara and Craig established at Pittsburgh in 1797 the first window glass plant to use coal.

The first really successful window glass factory in the United States was that of the Boston Crown Glass Company of Boston, Massachusetts. Chartered in 1787, it began operations in 1792, under very favorable conditions, being greatly assisted by the liberal action of the state legislature.

The legislature exempted the company from taxes and their workmen from military duty. It also gave them exclusive rights for fifteen years to manufacture window glass in Massachusetts.

In 1798, records show that this company produced window glass to the value of $82,000. The glass made at this factory was said to be superior to the imported article and was well known among the trade of that time as "Boston crown window glass." Specimens of this old crown glass can be seen today in many of the old Colonial houses in New England.

The use for glass for windows was by this time becoming widespread. The American pioneers who pushed their way across the western frontiers each carried a small four-paned window, which the homestead law of the time required to be built into every cabin.

This general use of glass was made possible by better methods of manufacture. The casting process for making flat glass never attained commercial possibilities. The first real window glass was made by the blowing process and was known as "crown glass."

HAND PROCESS OF MAKING WINDOW GLASS: BLOWING THE CYLINDERS

This process consisted in gathering a large globule of molten glass on the end of a blowpipe, the glass then being blown into hollow spherical shapes. Next a punty or iron rod, tipped with molten glass, was applied to the opposite side of the sphere and the blowpipe was detached, thus leaving a hole.

The globe attached to the punty was then reheated and the punty given a whirling motion that caused the glass to flash outwardly into the form of a disc, adhering to the punty by the boss in the center. The disc was removed from the punty, annealed in an oven and then cut into small sheets. The centers of the discs containing the bosses or "bull's-eyes" were used for decorative effects and were employed largely in the sidelights and transom lights of the Colonial doorways of New England.

This method of making flat glass was obviously very expensive and wasteful and furthermore did not make possible the production of anything but very small lights.

Sheets of flat glass made by the process described above were necessarily limited in size and very expensive. This furnished a great incentive to the study of modifications and development of the method so that larger sizes could be produced and at less cost.

The so-called "hand process" of blowing glass in a cylinder form and its subsequent flattening, as we know it today, is a slight advance over the old crown glass method. It is uncertain when this hand process was first started. Mention is made of its being used as far back as the eleventh century, but it did not come into general use until early in the nineteenth century. This hand process continued to be the accepted method for making window glass until about 1903.

A brief description of this process is of interest in order to indicate the great skill and arduous labor necessary to produce the so-called flat glass by this method.

The blower, gatherer and snapper constitute what is known as a "shop" in this trade. The gatherer, using a heavy blowpipe about five feet long, gathers a small ball of molten glass on the end, removes it from the furnace, blows it slightly and then gathers more glass. This operation is repeated four or five times until he gathers sufficient glass to produce a cylinder of the desired size. The ball thus gathered weighs from 20 to 40 pounds, according to the size of the cylinder to be produced.

The gatherer carries the blowpipe with the adhering mass of semiplastic glass to the "blower's block," an iron mold set in water and lined with charcoal to prevent the surface of the ball from becoming marred by direct contact with the iron. The gatherer then blows into the pipe while giving the ball and pipe a rotary motion on the block, at the same time pulling it upwards in an inclined direction. By this means the ball assumes a pear shape and thus forms what is known as the "neck" of the cylinder in which condition the pipe with the pear-shaped mass of glass is passed to the "blower" who reheats the mass at the blow furnace and then swings the pipe over the "swing hole," or alley, alongside of the furnace.

By highly skillful heating, blowing, reheating and dexterous manipulations, the cylinder is elongated, the sides being kept as nearly as possible to the desired thickness necessary to produce either single, double or heavier sheets.

These intermittent operations are carried on until the bottom of the cylinder is of the same thickness as are the sides. This closed end is then exposed to the heat of the blow furnace while the workman at the same time blows into the pipe and then, by placing his thumb over the end, confines the air under slight pressure. The air, being expanded by the heat from the furnace, finally bursts out through the bottom. The cylinder with its ragged, open end thus produced, is again swung out into the "swing hole" in such a manner as to make it completely cylindrical to the end.

The blowpipe with the completed

cylinder still attached by the neck is next passed to the "snapper" who removes the pipe by touching a cold iron to the glass close to the point of the pear-shaped neck or cap. The cap is then cut off by applying a thread of hot molten glass around the cylinder at the shoulder and again applying a cold iron. The completed cylinder, thus produced, is split open longitudinally by passing a hot iron back and forth along the inside and subsequently applying a cold iron. Cylinders thus formed vary in size from twelve inches in diameter by fifty inches in length to twenty inches in diameter and seventy inches in length.

The cracked open cylinder in this form is then ready for the "flattening process"—another very difficult and highly skilled step in the production of sheet glass by this method. The cylinder is laid on a light iron carriage and carefully introduced into the heated interior of the flattening oven and when sufficiently heated it is lifted from the carriage by long iron tools and placed on the flattening stone, a large, fire-clay slab with a well-polished surface. The split cylinder gradually softens and by means of other tools is spread out upon the stone and then ironed or flattended by rubbing with a block of wood mounted on a long iron handle.

The "flattening table" containing the stone is revolved and the stone then moved into a cooler chamber, another stone being moved into the hot flattening oven ready to receive another cylinder and the process repeated. The flattened sheet is now picked up by a long-handled fork and placed in the hot end of the annealing oven or lehr, through which it gradually passes, during the annealing process, towards the cool end. The sheets are then removed and dipped for a few seconds in a hot bath of diluted hydrochloric acid. This dipping process arrests any further action of the alkali that is used in the original glass batch and prevents the glass fading through the action of the elements.

A little reflection upon the physical characteristics of the split cylinder in passing from its cylindrical form to the flat sheet is interesting. It can readily be seen that in the flattening process previously described, the attempt is made to force the inside circumference to equal that of the outside. This is manifestly impossible since the glass cylinder is heated only to the bending point.

The result of this fact alone is that this ironing out or flattening process cannot produce an absolutely flat sheet of glass and the finished sheet will have an appearance similar to hammered brass or else it will be full of long irregular waves. Both conditions produce unpleasant effects of distortion when objects are seen through glass made in this way.

Other defects quite prevalent in cylinder glass, which of necessity requires the flattening process, are the "burns" or marks caused by the sheet of glass coming in contact with an excessively hot or dirty flattening stone. In addition to the foregoing and as a further result of attempting to make the outside and inside circumference of the cylinder equal in the flattened sheet the sheets are always noticeably bowed or bent.

LIBBEY-OWENS PROCESS: CLOSE-UP OF MACHINE

On this account the sheets of glass always have to be laid the same way in the packing boxes in order to minimize the inevitable breakage in shipment. Furthermore, in subsequent glazing, the glass made by this method, either by hand or by the more advanced cylinder machine process, must be placed in the sash with the bowed side out.

The hand cylinder process of making sheet glass has been the accepted method for many years and even in our present day of progress it is still used extensively in many countries of Europe, while in the United States approximately one-third of our window glass is produced by this method which, however, is fast becoming obsolete on account of the recent developments in the art.

It is evident that while the hand cylinder process is an advance in a commercial way over the old crown process, the method is still very expensive and obviously laborious and hard upon the workmen.

The artisans employed in the manufacture of sheet glass by this process have for years jealously guarded their trade, allowing only a limited number of apprentices. They have rigorous rules and regulations in respect to the teaching of these apprentices to follow in the footsteps of the older men, who are forced to abandon their trade prematurely because of its rigorous demands. Here again is seen ample reason for study and experiment in order to find a way of reducing this tremendous amount of arduous labor, and so work was begun in the early Nineties on a mechanical method for eliminating the human gatherers, blowers, and snappers.

It is therefore quite obvious that the logical method of making sheet glass is to make it in flat form at the outset. One naturally asks: "Why make it round and then change its form to a flat sheet?" Books could be written on the study and experimentation of drawing glass in sheet form. There is on file a British patent taken out by a man named Clark, February 19, 1857, and a very similar Belgian patent taken out by a man named Loup, March 12, 1857. These were followed by an extraordinarily large number of patents on sheet glass from that time to the present and it can be well said that there is hardly another industry today in which such a wealth of study, effort and money has been expended; and finally there was accomplished what the majority of practical glass men were ever claiming as the impossible —the Colburn sheet glass machine as perfected today by the Libbey-Owens Sheet Glass Company.

The inventor of the process, Irving

W. Colburn, became interested in glass in 1898 and started a small experimental plant at Blackford, near Philadelphia, Pennsylvania, where he worked on a machine for blowing lamp chimneys and tumblers. After working two years and expending $17,000 he abandoned this work and moved to a small plant at Franklin, Pennsylvania, where he interested some of his friends in assisting him to carry on his experiments from 1901 to 1905, on an idea he had for a machine to blow cylinder glass. His ideas proved to be merely fantastic dreams and while he did succeed in mechanically producing a few cylinders, they were of poor quality and the cost of operation was prohibitive. During these six years he continually had in mind the idea of producing glass in sheet form by mechanical means without the necessity of first making it in the cylindrical form. We find now that this idea has been in the minds of many glass men, both here and in other countries, for the past half century as evidenced by the array of paper patents on sheet glass, from the patents of Clark and Loup in 1857 up to the present day. It remained, however, for Colburn to give to the world the first workable machine producing commercial flat-drawn sheet glass. His first idea embodied in the present machine occurred to him in 1905 when he witnessed a paper-making machine in operation.

Colburn was a man who invariably had ideas in advance of his fellows and had the faculty of surrounding himself with close friends who always seemed willing to give a ready ear to his ideas as well as to assist him in a financial way. He discussed with many of these friends his ideas of making sheet glass, after having seen the paper machine in operation, and succeeded in securing additional financial backing; and in August, 1906, formed the Colburn Machine Glass Company. During the following two years he built many machines, crude at first, but gradually approaching a solution of the difficult problems with which he found himself confronted. With him, as with many inventors, success was always just ahead, leading him on like the will-o'-the wisp. He however, had the inventor's temperament, always hopeful, always confident of ultimate success and endowed with a wonderful determination to accomplish his end.

Strange as it appears today, the process was thought to be a success in 1908 and the Colburn Machine Glass Company granted a license for the use of one machine to a company at Reynoldsville, Pennsylvania. The newspapers of the day carried glowing accounts of the possibilities of the Colburn machine. The new plant started off under apparently very favorable conditions, but it was soon proved that the end of the journey was a long way ahead.

The trials and tribulations of Colburn and his friends during the following four years form a pathetic story.

Machine after machine, furnace after furnace, was built, torn down and rebuilt, until in all, from 1905 to 1912, fifteen different machines had been constructed and more than $1,000,000 expended with only a few thousand boxes of poor quality glass to show for the tremendous outlay of human effort as well as money.

LIBBEY-OWENS PROCESS: FEEDING THE FURNACES

In 1911 the credit of the Colburn Machine Glass Company was gone; the company was declared bankrupt and its assets, including the numerous domestic and foreign patents of Colburn, were put up at public auction on February 8, 1912, at Pittsburgh.

With the history of flat glass thus outlined it should be of interest now to consider in detail the Libbey-Owens process for making flat-drawn sheet glass.

The preliminary operations are very similar to those in other forms of glass manufacture. The mixture of the ingredients, called the batch, composed of sand, ground limestone, soda ash and salt cake, with a certain amount of cullet or broken glass, is fed into the furnace and melted under a heat of about 2,500 degrees Fahrenheit. The furnace contains from 600 to 900 tons of molten glass. This molten glass passes from the melting chamber to the refining chamber, where it is gradually settled or refined, preparatory to entering the shallow drawing pot from which the sheet is drawn.

This pot or pan is suitably placed in a pot chamber and supported upon silica brick stools. By means of heat applied underneath and around the edges of the pot, the temperature of the glass is carefully maintained at the proper degree of heat for the ultimate formation of the sheet.

To start the drawing of the sheet, the machine is placed in reverse motion, which allows a bait to be introduced into the drawing pot containing the molten glass. The bait is a simple affair consisting of a flat iron bar three inches wide and about six feet long, attached to strips of flexible metal that allow the bait to pass over the bending roll, down into the glass. The molten glass immediately adheres to this bar. Then the machine is placed in forward motion, thus pulling the bait with its adhering mass of plastic glass over the bending roll onto the horizontal flattening table and thence into the lehr. When the bait reaches the end of the flattening table, about ten feet from the bending roll, it is cracked off and removed and the sheet of glass is allowed to continue on its way through the 200-foot annealing lehr.

The natural question that arises when describing the formation of the sheet of glass in the Colburn machine is: "Why doesn't the sheet pull to a point? What is it that sustains it at a constant width?"

The answer is that the sheet is kept at an even width by passing the outer edges of the sheet between two sets of water-cooled, knurled rolls, placed an

(*Continued on page 122*)

HIGH PRESSURE STEAM AT WEYMOUTH

By I. E. MOULTROP

Assistant Superintendent Construction Bureau, The Edison Electric Illuminating Co. of Boston.

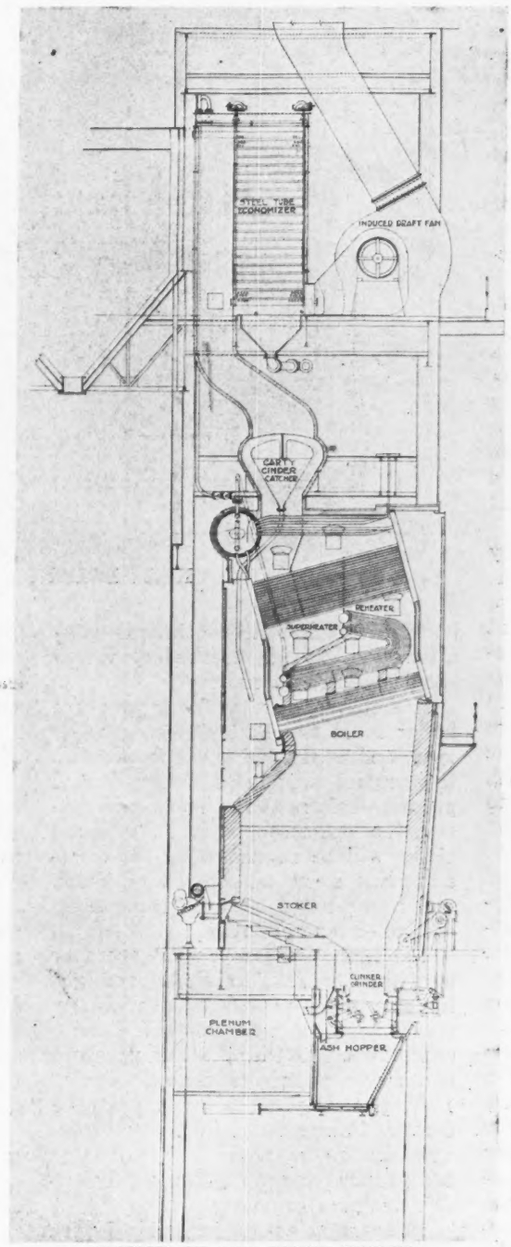
THERE is being installed at the Weymouth power station of The Edison Electric Illuminating Co. of Boston, the highest pressure commercial steam power plant in the world. The equipment will develop about 15,000 kilowatts of electrical power from steam at a pressure of 1,200 pounds per square inch. This installation forms what is called the "base load," part of the power generating plant, for it will carry that portion of the load that is normally constant. The larger, "peak load," part of the station which will operate at a steam pressure of 350 pounds per square inch will carry the load that fluctuates due to changes in the demand for power.

The term "high pressure steam" is not a new one by any means, for nearly all the developments of steam engineering have been so described. The first steam plant of which we have any record was built in Egypt about 130 B.C. for grinding corn. This, by the way, was a true turbine installation; but it was so far ahead of its time that the invention lay neglected for eighteen centuries. About 1700 A.D., the first crude steam engines were built for pumping water from English mines. These used steam pressures as high as 140 pounds per square inch.

We are told, however, that the inventor was "at the pains and charge, to have all the joints soldered with spelter," as the heat melted the common solder. One can readily believe it. Probably due to the combination of solder and hot steam, steam pressures were greatly reduced when Newcomen and Watt introduced the steam engine as we know it today. For a long time thereafter, the boiler pressure did not exceed a few pounds and boilers were not much more than large kettles.

As late as 1872, steam pressures were limited to fifty or sixty pounds. From this time, however, the demand for greater efficiency brought ever-increasing pressures and temperatures. At the beginning of the recent war period, they ranged from 200 to 250 pounds; with temperatures in the neighborhood of 500 degrees Fahrenheit.

Following the war there came a marked development in the design of steam machinery. The steam turbine had been developed to great effectiveness, and made possible steam conditions and efficiencies not before attained commercially. Pressures increased rapidly until the standards for large power stations reached the range of 300 pounds to 500 pounds used today. This rapid increase in "high pressure steam" invited further progress and engineers began seriously to consider pressures above a thousand pounds. Two noteworthy plants of this type have been constructed for experimental purposes. The first is in Sweden operating at 1,500 pounds per square inch, and the second, the Benson plant in England, which generates steam at 3,200 pounds per square inch and reduces the pressure to 1,500 pounds for operation. Both plants have been successfully operated, but none of this machinery is strictly for commercial power generation. It was not until the design of the Weymouth station was undertaken that steam at a pressure above 600 pounds was utilized for developing a large amount of commercial power.



SECTION OF 1,200 POUND BOILER

The high pressure installation at the Weymouth power station consists of a boiler and turbine designed to operate at a maximum steam pressure of 1,200 pounds per square inch. The boiler generates the steam and superheats it to 700 degrees Fahrenheit total temperature and then delivers it to the turbine. From the turbine the exhaust at 360 pounds pressure returns to the boiler where its temperature is again raised to 700 degrees Fahrenheit. The steam is then delivered to the main steam header for use in the normal pressure (350 lbs.) turbo-generators. The high pressure boiler and high pressure turbine are operated together as a unit.

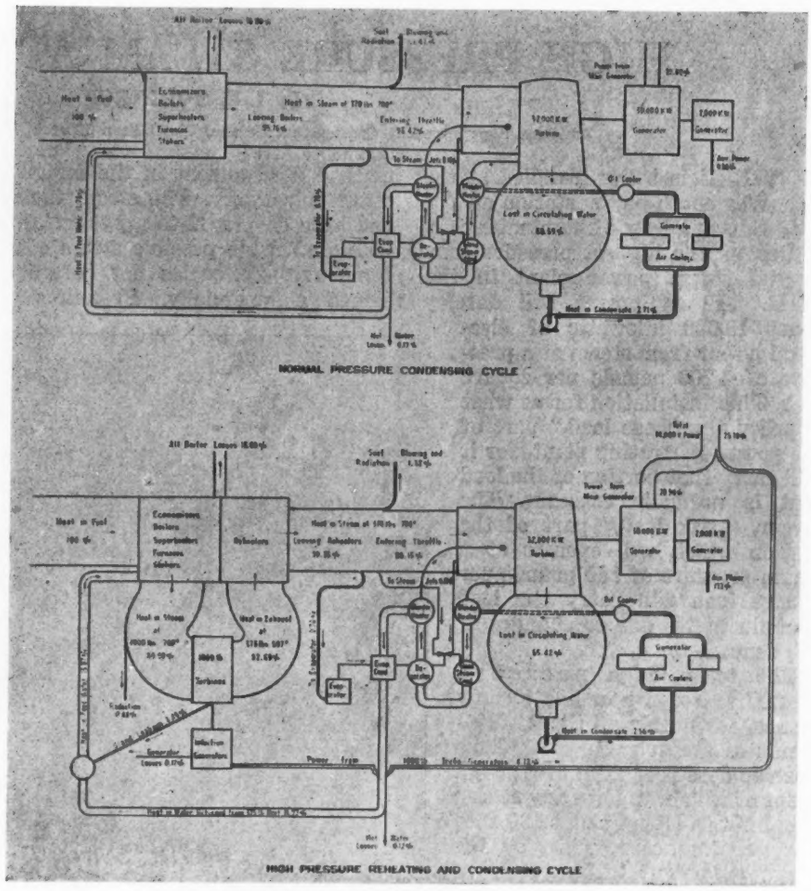
While 1,200-pound steam represents a marked increase in pressure over former practice, the actual installation involves little that is radically new. The theory on which the design is based is well established. The equipment to be used follows the best present designs modified to care for the higher pressure. These designs have been fully proven by years of operation and it is expected that experience with high pressures will indicate only minor adjustments of design.

The 1,200-pound steam boiler is a modification of the conventional Babcock & Wilcox cross-drum type, the heating surface consisting of two-inch tubes, fifteen feet long, arranged in three passes. The drum is a solid steel forging thirty-two feet long by four feet in diameter, with walls four inches thick. This

enormous forging was made in the gun works of the Midvale Steel Co., and received the same care as the guns for our superdreadnaughts. The tubes are separated into upper and lower banks, with a primary superheater between. Above the upper bank of tubes, is a secondary superheater or reheater. The tubes of this reheater are at right angles to the tubes in the main heating surface and are so arranged that the gases pass through them between the first and second passes of the boiler. The main boiler baffle between these passes is extended up into the reheater by means of an adjustable damper. When this damper is in the lowest position, all the gases are forced to pass through the reheater. When the damper is raised to its highest position, the reheater is by-passed and is practically out of service. Intermediate positions of the damper give varying degrees of effectiveness to the reheater.

The boiler is fired by Taylor stokers. These are of the conventional type which feed coal on to the grates by a series of plungers and then gradually work it down as it burns. When only ashes remain, these are delivered to a set of crusher rolls which grind the ash and clinkers to convenient form for removal, and deposit them in bins below the furnaces.

A special arrangement of safety valves is used to protect the boiler. The cross-drum is provided with a series of safety valves, set to blow at 1,200-pound pressure. In order to protect the primary superheater, a safety valve is placed on its outlet and set to blow at 1,190 pounds. It is possible that after operating, the seats of these valves would be seriously damaged, which would render it necessary to shut the boiler down and reseat the valves before continuing operation. In order to avoid undesirable wear of the seats of the main valves, a warning to the fireman is provided consisting of two telltale or "sentinel" valves. These are placed on the discharge from the primary superheater and are of small diameter, set to blow at 1,170 pounds per square inch. Between them and the steam connection, are placed gate valves. In operation, one of these gate valves will be closed; the other open. Should the pressure rise near the 1,200-pound point, the first sentinel valve will blow, giving the fireman an opportunity to reduce the pressure on the boiler in time to prevent the main valves from blowing. The sentinel valve which has blown can then be shut off by the gate valve below it, and the other put into service by opening its gate valve. The first sentinel may then be removed and reseated if necessary. In this way, the boiler can be kept in continuous operation even though the safety valves should require special care.



HEAT BALANCE DIAGRAM

The control for the high pressure boiler is of the Bailey electric relay type, and is similar in all respects to the control supplied for the normal pressure boilers at the Weymouth station. In operation, that 1,200-pound boiler will be regulated by the semi-automatic electrical controllers, which will be operated by push buttons on the boiler control board.

The high pressure turbo-generator is of the General Electric Co. straight impulse type, provided with twenty stages, each stage having a single row of buckets. The initial steam pressure is variable, with a maximum value of 1,200 pounds per square inch at 700 degrees Fahrenheit total temperature. The exhaust pressure is constant at 360 pounds per square inch, with variable temperature.

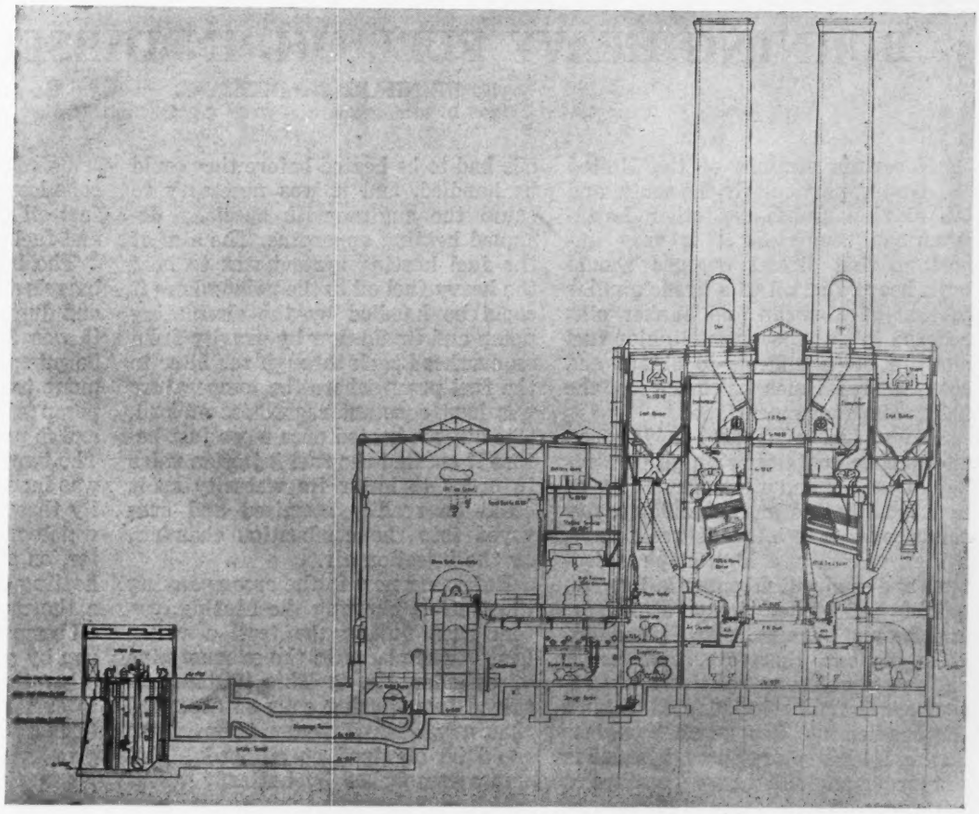
The turbine casing is provided with shaft packing glands at both high pressure and exhaust ends. There are two leak-off points from these glands. The first leak-off delivers steam, at a maximum pressure of twenty-six pounds absolute, to the closed feed water heater, connected to the twelfth stage of the 350-pound pressure turbo-generator with which the high pressure turbine is operating. The second leak-off is connected to a surface condenser at atmospheric pressure, which is connected into the condensate return system of the 350-pound unit.

The turbine governor is of the conventional type, but designed so that the synchronizing spring has sufficient range to place the governor completely out of action when desired, during normal operation of the unit. This arrangement of governor is desirable as the turbo-generator will operate at all times at its maximum load for the steam pressure carried. Its output will be governed only by the boiler pressure, while its speed will depend on the main electrical system to which it is connected.

There will be an emergency overspeed shut-off device connected to an oil-operated trip latch on the throttle and by-pass valves.

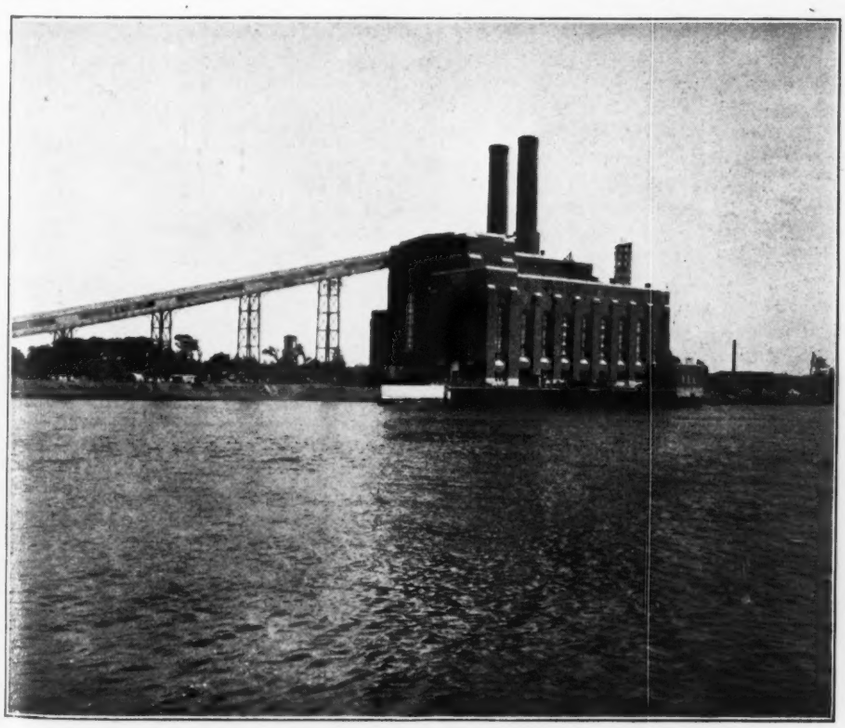
The piping for the installation is of very simple design. It consists of a single high pressure line, connecting the primary superheater outlet nozzle on the boiler to the turbine throttle, an exhaust line connecting the turbine exhaust to the reheater inlet on the boiler, and a third line, connecting the reheater discharge on the boiler to the

main steam header. Between the high pressure steam line and the exhaust line is a by-pass around the turbine supplied with a desuperheater. In general, the flow of steam is from the boiler drum, through the primary superheater to the high pressure piping. At the outlet of the primary superheater, a motor-operated gate valve is supplied, for use as a stop valve in normal and emergency service. No stop check valve is supplied, as no other boilers are connected. After flowing through the turbine, the steam is returned to the reheater in the boiler, and, after passing through this, flows to the main steam header. A stop check valve is provided on the outlet of the reheater, in order to prevent steam from the main header flowing back into the reheater. A simple check valve is supplied in the exhaust line from the turbine, in order to prevent steam discharged from the by-pass from flowing back through the exhaust connection into the turbine. A conventional stop valve is provided where the steam enters the main header.



A CROSS-SECTIONAL PLAN OF THE WEYMOUTH STATION

In the by-pass around the turbine, a special type of trip valve is installed. This valve is similar in design to the turbine throttle, and is equipped with an oil-operated trip gear, but this trip is designed so that the valve will open instead of close when actuated. This trip gear is placed in parallel with that on the turbine throttle, the purpose being to by-pass the steam immediately should the turbine throttle be closed by the overspeed device. Beyond the by-pass valve, is inserted a nozzle for throttling the 1,200-pound steam and expanding it to 360-pound pressure before it enters the exhaust line and is returned to the boiler reheater. Beyond this nozzle are placed a series of water jets for desuperheating the steam. These jets receive water from the 425-pound pressure boiler feed line, through a small trip opening valve operated by the trip on the by-pass valve. Both the by-pass valve and the desuperheating water supply valve can be manually operated at any time.



A GENERAL VIEW OF THE WEYMOUTH POWER STATION

In starting up the high pressure plant, steam will be raised to a moderate pressure in the usual way. During the period of warming up, the by-pass valve will be kept open allowing part of the steam generated to flow through the boiler reheater into the 350-pound steam system. When the high pressure turbine has been brought up to speed, the by-pass valve will be closed and the pressure raised to 1,200 pounds per square inch. The high pressure system will then operate continuously at its rated load. During operation, power will be delivered from the gen-

(Continued on page 124)

BURNING HEAVY FUEL OIL IN DIESEL ENGINES

By REINHARD HILDEBRAND
Chief Engineer, Diesel Division, Fulton Iron Works Co., St. Louis, Missouri

IN certain sections of the United States, particularly the south, and also in Cuba and other Latin-American countries, it is very important that Diesel engines should burn heavy fuel oil of a grade similar to that of Mexican and bunker oils, because in these localities lighter fuel oils are often difficult to obtain and cost several times as much as the heavy oils above mentioned.

Heavy fuel oils such as Mexican and bunker, containing a high percentage of carbon and a low percentage of hydrogen, have a high specific gravity corresponding to a low degree Baume, a high viscosity, a high sulphur content and their flash point is low, requiring a higher temperature for ignition and burning, than lighted oils. It is obvious, therefore, that larger engines running at relatively low rotary speed are better adapted to burn the heavier oils than smaller engines having a high rotary speed, because in the larger engines the temperature in the combustion chamber is higher and the time available to convey the fuel oil into the combustion chamber and to burn fuel, is longer than in smaller engines. For these reasons the manufacturers of Diesel engines generally will not find it difficult to run their larger, slow speed engines on heavy fuel oils, while in most cases they experience considerable trouble with their smaller high-speed engines when burning heavy oils.

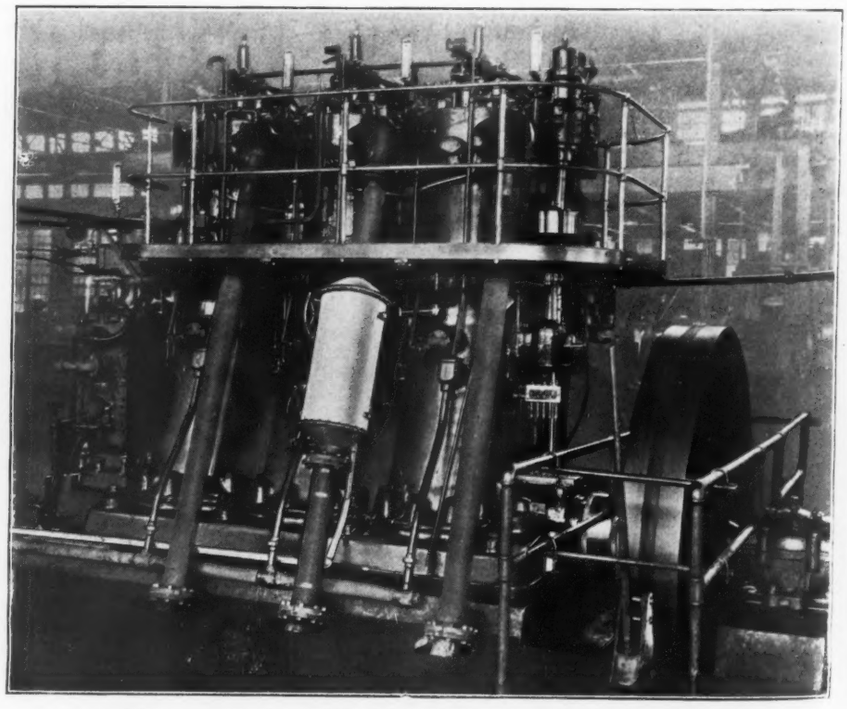
It is a fact that some Fulton-Diesels have been operated for several years on Mexican oils, although they were not built to burn heavy oils. Now Fulton-Diesels are designed to burn heavy fuel oil and the Fulton Iron Works Company has recently made exhaustive shop tests, with a small three-cylinder, single acting, four stroke, vertical Diesel, having 13½-inch x 19½-inch cylinders, developing 200 B.H.P. at 257 R.P.M. The results obtained with this engine while running on Mexican and bunker "C" oil have been most gratifying. There was no trouble whatsoever in obtaining absolutely clear exhaust from no load up to 20 per cent over-load, the engine taking the heavy fuel oil just as readily as lighter oils. The consumption of the heavy fuel oil compared with the light, was in proportion to their heat values.

The tests were made during the cold weather which prevailed during the months of January and February of this year. Of course, the heavy fuel oils had to be heated before they could be handled, and it was necessary to equip the engine with specially designed heating apparatus. The aim of the fuel heating system was to heat the heavy fuel oil to the point where it could be handled by the circulating pump and would flow by gravity from an overhead tank through the filter to the fuel pump where the temperature was kept constant regardless of load. The oil was heated once more just before it entered the fuel injection valve in order to lower its viscosity so it could be readily atomized and conveyed into the combustion chamber, by the injection air.

Referring now to the accompanying illustration, showing the heating system used during the test, a water heater was placed in the exhaust pipe of cylinder No. 2. This heater contained two heating coils so arranged that any desired water temperature could be obtained at all loads. This was accomplished by butterfly valves which could by-pass the exhaust gases more or less, as desired. Thermometers were attached at the inlet and outlet of the heating coils. The water was circulated by a pump and distributed through the various heating coils located in the fuel oil sump tank, fuel oil filters, overhead service tank and fuel pump.

The heavy fuel oil was brought in barrels to the engine during the test and dumped into the sump tank. Here it was heated sufficiently so it could be pumped by the fuel oil circulating pump to the overhead tank. The latter pump is built integral with the engine and is part of its standard equipment. The temperature of the oil in the tank was increased so it could flow by gravity through the twin fuel oil filter, of which only one side was used. This filter, as stated above, also contained a heating coil and it was equipped with a thermometer to determine the fuel oil temperature. From the filter the oil ran by gravity to the fuel pump. Another thermometer was attached just in front of the fuel pump where the temperature was at all times kept approximately constant. From the fuel pump, the oil was discharged through a heating coil located in the exhaust port of the cylinder head, from whence it passed through a check valve into the fuel valve.

(Continued on page 118)



A DIESEL ENGINE DESIGNED TO BURN HEAVY FUEL OIL

Great economy is obtainable with this type of engine. It will burn fuel costing about 4 cents per gallon in place of the usual light Diesel fuel oil at 17 cents a gallon.

EDITORIALS

MORITUROS VOS SALUTAMUS

The popular conception of Technology seems to be that it is a work-house or a factory in which engineers are produced in much the same, cold, impersonal manner as are automobiles or sewing-machines. In extending a greeting to the members of the class of 1928, we wish to say just a word concerning this reputation.

Throughout the country Tech is considered the finest engineering school. Such a pre-eminence cannot last, if it is a mere popular fancy and not substantiated. The success of our alumni has not only sustained but constantly increased this prestige. They have impressed their superiority upon the nation, and their renown has been shared by their Alma Mater. Their admiration and belief in the worth of the Institute is shown by their generous financial support of its program of expansion.

As we come to know the graduates, we find that the majority of those who have been successful were not grinds during their undergraduate years. Moreover, some of them were constantly in conference with the Dean. These men did not find Technology a "sweat shop." They were interested in their studies, but realized that there were other factors in Institute life almost as important in the development of an engineer. They engaged in activities and sports and mingled in social life. In short, they lived well-rounded lives and their experience at Technology gave them the keen preception and the power to evaluate men and affairs, which helped them to attain the prominent positions which they hold today.

Tech was to them a very human, extremely pleasant and intensely interesting place to pursue their engineering studies. And it is this sort of a Technology that will arouse your admiration and devotion if you start upon your Institute career with a spirit of enthusiasm and interest. Learn to study economically, choose your friends carefully, and acquire habits of pleasure worthy of a gentleman. If you follow this, you will not become a *grind*—that abhorrent creature, who adds nothing to the life of the Institute and consequently derives nothing from it.

THE METRIC SYSTEM

A bill was recently introduced in the United States Senate which has for its purpose the establishment of a decimal system of weights and measures. Its principal features are the retention of the foot as the linear base, the establishment of the ounce as the weight of "the cube of a tenth of a foot of water at maximum density" and the pint as the volume of a pound of water. The secondary units such as the yard, gallon and bushel are to remain practically as at present.

This bill was probably drawn up with a view to attaining the simplicity of the French metric system and at the same time not offending those prejudiced against the introduction of foreign ideas and the destruction of American institutions. It is an admirable compromise, but it does not go far enough. It retains too much that is undesirable in the present system to make it worth the momentary confusion that will follow any change in our standards. Even the fact that the old and new units are nearly alike is a strong argument against the new. In the event that a change is made, the simplest system yet devised should be adopted, regardless of where it originated.

The English system resulted solely from custom. Its units were devised by tradesmen and artisans to fit their particular needs and there was no real reason for having a simple relationship between them, for precise sciences were as yet unknown. The yard is supposed to have been the length of an English monarch's arm. This unit was too large so it was divided into thirds. To have a relationship between the pound and the foot through the medium of some common substance such as water was never considered. It was not until the time of James Watt that any thought was given to the establishment of a system which lent itself to rapid and accurate calculation. His system was much the same as the present metric method of measurement which Revolutionary France, bent on abolishing all that smacked of the old regime, established as its legal standard.

The metric system is undoubtedly the simplest in use today though it is by no means perfect, for it made no change in the units used in measuring time or angles. It is almost universally used in Chemistry, Physics and the exact sciences because of its extreme simplicity compared to the English system. In engineering work, specifications are made in English units because they are the standard in manufacturing and commerce. If the metric or a similar method were adopted as the legal standard, all our engineering calculations would be made infinitely more simple.

It is to be hoped that any new system of weights and measures will abolish most of our present conglomeration, establish as simple relationship between standards of length and mass, and adopt a nomenclature for the secondary units, which will indicate their relationship to the standard. For these are the features of the metric system which make it so highly desirable.

OUR PROFESSORS

It is an almost uncontroverted fact that the professors in our universities deserve more credit for the development of our civilization both in point of intellectual ability and scientific accomplishments than any other group. Theirs is one of the most unselfish branches of human endeavor and their devotion and loyalty to the cause of learning are incomprehensible in this material age.

At Technology, we are particularly fortunate in having leaders in the various branches of science and engineering as lecturers and even for class room recitation. We appreciate their interest and ability and it is with halting speech and fear of being misunderstood that we venture any criticism.

Authorities on education believe that even the most efficient teacher can only impart fifty per cent of his knowledge of a subject to the most brilliant student. And the chief factor in reducing the efficiency of a professor is his method of delivery. Learned lecturers fail to make an impression because the perception of the audience is dulled by the monotonous tone or the inaudibility of the lecturer. All men cannot be witty or carry their audience with them by their enthusiasm, but anyone can give his subject an even chance of being understood, by acquiring a clear, well modulated manner of speech.

MONTHLY NEWS

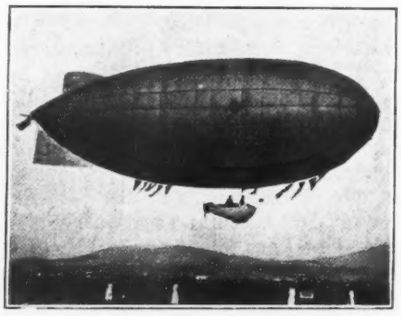
New Italian Semi-Rigid Airship. The new Italian type "Mr" airship is the smallest semi-rigid airship in the world. Up to the present it was believed that only non-rigid airships could be produced in very small volumes; in 1917 prominent technicians had affirmed that it was impossible to construct a semi-rigid of 2600 cu.m. capacity. The Aeronautical Engineering and Construction Division of the Italian Air Force proved the erroneousness of this when it produced the SCA type airship, the volume of which was 1520 cu.m. This record has recently been surpassed with the construction of the "Mr" semi-rigid, the actual volume of which is less than 1000 cu.m.

Due to the extremely small dimensions of the ship, the difficulties of construction were innumerable. It is a well-known fact that the percentage of useful load of an airship decreases in proportion as the volume decreases, and that a limit exists where the ship can no longer lift its own weight. For this reason, the "Mr" must be considered a triumph of Italian constructive technique.

The "Mr" has an actual capacity of 960 cu.m. (33,888 cu. ft.) and carries a useful load of 450 kg. (990 lb.) or 42.5 per cent of the total lifting force, while the smallest non-rigid airship in the world, the French "Zodiac," which has a volume of 1000 cu.m. (35,300 cu. ft.) carries a useful load of only 260 kg. (572 lb.) or less than 24 per cent. The new Italian ship will normally fly at 65 km.-hr. which is five kilometers faster than the French ship.

The new airship may be usefully employed for scouting within a certain radius of action; its base may be either on land or on a mothership. Its very small dimensions permit its radius of action to be increased and so are not a disadvantage; in fact, its minimum bulk and limited means necessary for up-keep and operation greatly facilitate transportation from point to point, which may be accomplished even with motor-trucks. In this respect it is interesting to learn that the Spanish Navy has effectually used two SCA type airships in the Moroccan operations, housing them in motherships.

The airship is equipped with one 40 h. p., six cylinder, Anzani radial engine which has a fuel consumption of about 26 lbs. per hour. The Anzani engine will be replaced with a power plant of greater reliability and lower fuel consumption. The propeller is reversible through a clutch so that landing may be effected in a very small space. The car is suspended from the keel by means of steel cables; the pilot may control both the direction organs and the engine. Consequently it may be operated by only one man. Its maximum endurance with only one man aboard would be 25 hours covering about 930 miles.—*Aviation.*



THE ITALIAN SEMI-RIGID AIRSHIP "Mr"

Alaskan Paper Industry and Water Power. It is only a question of time when the shortage of newsprint paper stock in the United States and Canada will compel the manufacturers to go to southeastern Alaska for their pulp timber, declares J. C. Dort, Hydroelectrical Engineer of the Forest Service.

The two National Forests in Alaska can produce about 2,000,000 cords of pulp wood every year for all time under scientific forestry practices. Translated into paper this means an output of 5,000 tons of paper every day. Excellent water power sites are abundant in southeastern Alaska.

Under the procedure adopted by both the Forest Service and the Federal Power Commission the sale of timber and the leasing of power sites are linked together, the National Forest areas having been allocated to provide ample timber supplies for all time to cover any possible needs of arising from leasing water power sites located within such forest areas.

Recent surveys show that the Forest Service's early rough estimate of 70 billion board feet as the amount in the Tongass National Forest was conservative. With large timber supplies that can be made to produce 2,000,000 cords of pulp wood annually on the sustained-yield basis, or roughly, 5,000 tons of paper a day, with thousands of miles of sheltered inland waterways that favor economical logging and transportation, and with large resources of water power that can be developed at a relatively low unit cost, the prospects of a rapid and substantial growth of this new industry in southwestern Alaska are bright indeed.

Trunk Line Highways for Trucks. New types of highways for motor cars are predicted by Major Elihu Church, Transportation Engineer of the New York Port Authority. These will be trunk-line highways extending over the country similar to the trunk-line railroads. There will be separate roads for trucks and passenger cars. Predictions are made of trains of tractors and trailers on the highways, the trailers controlled by air brakes just as railroad cars are, the truck trains being dispatched over the roads as a train dispatcher handles his trains.

Weather Reports as Fire Alarms. In the forest as in the city, the quicker a fire is reached the less it costs in time and men and damage to put it out. Since distances to be covered on our National Forests are vast, to be forewarned of particularly dangerous fire conditions in certain areas enables the Forest Supervisors to place men and supplies in advance of fire outbreak, ready to respond to the first "smoke" sighted. For this reason a close cooperation between the Weather Bureau and the United States Forest Service is being worked out, by which weather predictions as far in advance as possible are furnished direct to Forest Supervisors on the National Forests. For Montana, Wyoming and Idaho, forecasts are sent out daily from Chicago to Spokane, Helena and Boise, where they are relayed to the nearest group of Forest Supervisors.

Thin Wire for the Delaware Bridge. Twenty-five thousand miles of wire, the strongest of its kind ever made, which, when tempered, cuts ordinary steel as diamonds cut glass, will be used in the two cables supporting the world's longest suspension bridge, now being erected across the Delaware river to link Philadelphia, Pa., and Camden, N. J. The wire, long enough to girdle the globe, is shown by tests to have a tensile strength of 223,000 pounds per square inch of gross section, and, after assembly into the cables, it will hold at anchorage against a pull of 36,000,000 pounds.

The total length of the Delaware river bridge, including plazas, is 9,760 feet, as compared with the 5,989-foot length of the Brooklyn bridge, which was considered an engineering wonder of the world when it was erected. The main span of the Delaware river bridge—the span directly supported by the cables—is 1,750 feet. The river span of the Brooklyn bridge is 1,595.5 feet long. An idea of the progress effected in suspension bridge construction is given in the fact that four cables 15.5 inches in diameter are used to support the Brooklyn span, while only two, 29⅞ inches in diameter, will be used to hold up the Delaware span.

Each of the two Delaware bridge cables, after assembly in the field, will be 3,550 feet long with a sectional area of 562 square inches. Each will weigh 3,500 net tons, and be comprised of 61 strands of 306 wires each, or 18,666 wires per cable.

Before the wire is galvanized with zinc 99.75 per cent pure, the wire is required to measure 192/1000 of an inch in diameter, and this must not vary more than 3/1000 of an inch. It must coil cold around a rod one and one-half times its size without a sign of fracture. The galvanized coating is not allowed to vary from 3/1000 of an inch in thickness, and after it is applied the wire is again tested by being bent cold around a mandrel two inches in diameter without cracking the zinc coating.

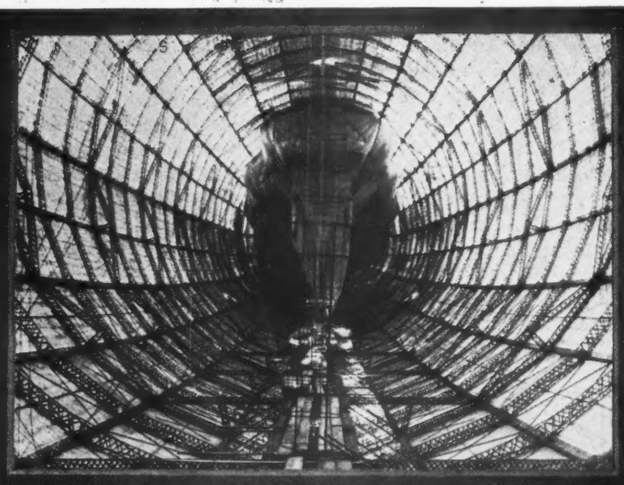
German Light Plane. A German firm has brought out a remarkable light aeroplane powered with an 18 h.p. Douglas engine. It is a cantilever monoplane with the wing built in two pieces, and is carried parasol fashion by a cabane of six steel struts. The pilot's cockpit is situated under the wing. The fuselage is plywood covered, and has a small locker for baggage. The machine is said to be extremely safe and easy to fly, and has been designed for simplicity of upkeep and ease of transport and stowage. The wings can be taken down and folded against the fuselage, where they are held by suitable locking devices, by one man in two minutes.—*Aviation.*

Steel Corrosion Tests by Ultra-Violet Rays. In recent tests made in the Bureau of Standards, the effect of ultra-violet rays upon polished metal surfaces was observed by allowing the rays to play upon a small area of the surface, the remainder of the surface being shielded by a thin metal sheet. Specimens of Armco iron, medium-carbon steel, "stainless" steel and high-nickel steel were exposed for eighteen hours to the ultra-violet rays, the result being a pronounced change in the exposed area. When the specimen is cooled and the moisture of the breath is allowed to condense on the surface, the exposed area becomes visible at once, the drops of the condensation being larger than on the unexposed parts and the surface looking as though a film of oil had been spread over it so that it is not wetted so easily as the rest of the surface. In the medium-carbon steel, very noticeable corrosion of the exposed spot occurred after four condensations of moisture, while the remainder of the surface was hardly attacked. Chromium and nickel steels did not show any corrosion, although the same difference between exposed and unexposed areas was noticed.—*Power.*

New Sulphuric Acid Process. The Schmiedel process for making sulphuric acid is a recent importation designed to work efficiently on gases of variable or very low sulphur dioxide content. It employs the familiar nitric acid as oxidizing agent, but dispenses with the chamber, for which it substitutes mechanical means of securing thorough and intimate contact between gases and reagent. A revolving drum, dipping into the acid bath, presents a thin and constantly renewed film of acid to the gas stream, which also necessarily comes in contact with the bath itself. The process is offered for the treatment of gases as low in sulphur dioxide as 1.5 per cent, and in capacities as small as five tons of acid per day, and is designed to produce any strength up to 60 degrees Baume. It may find considerable use in adding to outputs of existing chamber plants, or as a substitute for them, but its special appeal is to the metallurgist whose attention is fixed on contents other than sulphur, and whose furnaces are not running primarily to supply a gas of uniformly high sulphur dioxide content.—*Mining and Metallurgy.*

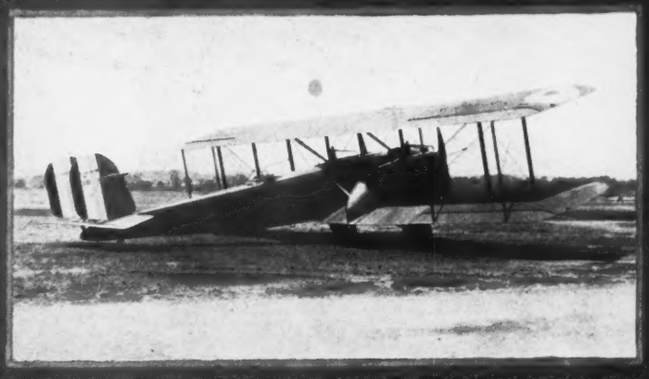
THE DELAWARE RIVER BRIDGE

The foot bridges are shown in place preparatory to stringing the cables from which the roadway will be suspended.

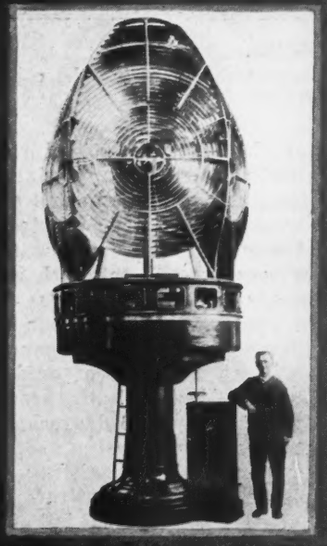


AN INTERIOR VIEW OF THE DIRIGIBLE ZR-3. THIS PICTURE SHOWS THE STRANGE APPEARANCE OF THE GAS BAGS. THEY RESEMBLE SOMEWHAT THE HEAD OF AN ELEPHANT.

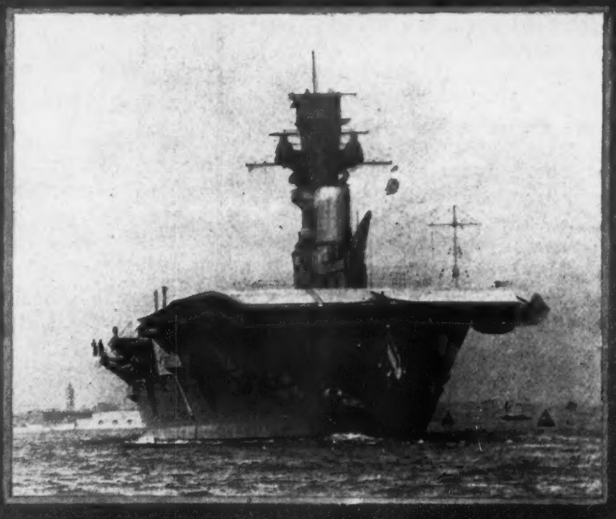
A DIRECT HIT ON THE FIRE CONTROL PLATFORM OF A BATTLESHIP DURING BOMBING TESTS. THE PHOSPHORUS BOMB SHOWS IN A STRIKING MANNER THE MENACE TO SHIPS FROM MODERN BOMBS.



THE NEW ELIAS BOMBING PLANE. IT CARRIES FIVE MACHINE GUNS AND 7000 POUNDS OF BOMBS AT A SPEED OF 105 MILES AN HOUR. THIS MACHINE HAS A GLASS FLOOR IN EACH OF THE COMPARTMENTS.



[illegible] LIGHTHOUSE LANTERN WHICH FLASHES A BEAM OF LIGHT 93 MILES. 1267000 BRITISH CANDLEPOWER SENDS A TRIPLE [illegible] 20 SECONDS



STERN VIEW OF H.M.S. HERMES, SOMETIMES CALLED THE UGLIEST SHIP IN THE BRITISH NAVY. THE HERMES IS AN AIRCRAFT CARRIER.

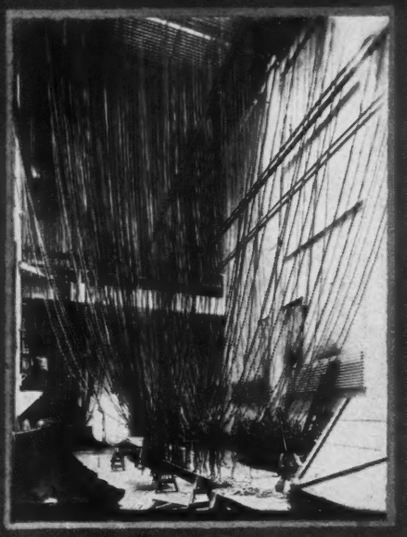
ALL PICTURES BY [illegible]

THIS CLOCK TELLS THE HOUR, THE DATE, THE MONTH AND SHOWS THE RELATIVE POSITION OF THE EARTH, THE SUN, AND THE MOON. EXIBITED AT THE HOROLOGICAL INSTITUTE CONFERENCE AT CHICAGO.

ONE OF THE LARGEST COAST DEFENSE GUNS IN THE UNITED ST... RECENTLY INSTALLED AT FORT TILDEN, N.Y. THIS SIXTEEN INCH GUN SHOOTS A PROJECTILE WEIGHING 2400 POUNDS.

LOCATELLI'S PLANE AS IT APPEARED ON THE HOP TO GREENLAND. NOTE THE DIFFERENCE BETWEEN THIS PLANE AND THE USUAL TYPE OF AMERICAN PLANE.

A NEWLY DEVELOPED 16 INCH HOWITZER. GUN AND CARRIAGE WEIGH 525,000 POUNDS. WITH A POWDER CHARGE OF 335 POUNDS A 2310 POUND PROJECTILE IS THROWN A DISTANCE OF FOURTEEN MILES.



AN IDEA OF THE QUANTITY OF ROPE REQUIRED IN A BIG THEATRE IS GIVEN IN THIS PICTURE. THOUSANDS OF FEET OF ROPE ARE USED FOR QUICK AND SILENT SCENE SHIFTING.

THE TRANSMISSION OF PHOTOGRAPHS BY RADIO

(*Continued from page 96*)

light cell four hundred times while the "slow" plate rotates once, equivalent to a hundred lines to each inch of the picture.

Thus every part of the image eventually falls on the light-sensitive cell. As the electrical resistance of the cell varies in proportion to the intensity of the light which falls upon it, the high lights, halftones and shades which make up the picture are converted into a correspondingly modulated electric current, which is then put on a radio carrier wave and broadcast.

Now to receive pictures by radio it is only necessary to cover a photographic plate in parallel adjacent lines, and to vary the density of the lines in proper order to build up the shadows, the halftones, and the high lights of the picture.

My mother entertained me a long time ago by putting a penny under a paper, and by drawing straight lines over it with a dull pencil made the Indian appear. That is very much the way in which radio photographs are made, but instead of a lead pencil a pencil of light is used and instead of white paper a photographic negative is employed.

The rotation of the prismatic plates draws the lines by causing the image of a point of light, an incandescent filament for example, to traverse the negative until it is covered, the incoming radio signals causing a fluctuation of the intensity of the point of light which varies the density of exposure of different parts of each line. The spot of light looks very much like a tiny twinkling star as it travels over the photographic plate, building up the areas of different densities. This plate, when developed, becomes a negative of the picture, object or scene at the sending station, and from which paper prints can be made as in ordinary photography.

The radio camera takes the usual plate holder, loaded with glass or film, and it is upon this the radio-fluctuated incandescent filament is imaged, through the rotating prismatic plates. To conserve the radio energy the "hook-up" for a filament lamp consists of a battery to bring the filament to a red glow. The incoming radio signals are put through the battery and lamp to variably increase the glow of the lamp to photographic values, corresponding to the light values of the different parts of the photograph at the sending station.

Of course, other sources of light might be employed or a steady light, a light-valve, instead of the radio-modulated light source, but the principle is the same, and the latter is much simpler. Any good modulating radio set with two or three stages of amplification is sufficient, the tiny lamp of the camera being attached to the set where one would attach a loud speaker.

It is immaterial whether the modulation is taken from a flat photograph, from a solid object, or from an outdoor scene at which the lens of the transmitter at the sending station is pointed, or sketches, drawings, hand or typewritten letters, and on cut sheets, or on photographic strips many feet long. The Chinese Minister, Alfred Sze, last year sent the first radio message in native characters ever sent by one Chinese to another. Later the Japanese Charge d'Affairs, Isaburo Yoshida, similarly sent a radio message in Japanese characters.

Incidentally the prismatic plate apparatus has been employed to send photos over wire and again by directed radio along a railroad rail. On October 4, 1922, photographs were sent through a telephone in the office to the Navy Radio Station, NOF, where it was broadcast, and picked up some twenty miles away.

In this demonstration the picture characteristics were converted by a light cell into electrical modulation; then into sound by a headphone ear piece; then into wire current by a microphone, and carried through two central telephone exchanges; then into radio current, and broadcast; and finally back again into light characteristics, by a radio camera, and recorded on a photographic plate with remarkable fidelity to the original photograph at the sending machine.

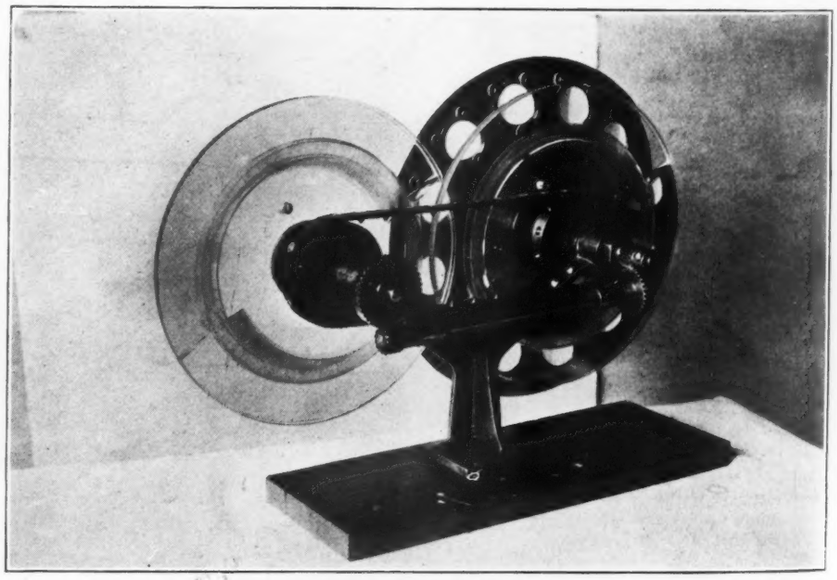
In March, 1923, photographs were again sent by radio from the Naval Radio Station, at Washington, to the *Evening Bulletin*, in Philadelphia, the sending machine being operated entirely by Navy personnel.

These experiments were not so strange if one remembers that the sending set simply changes picture values into electrical values, just as a carbon transmitter changes speech characteristics into electrical modulation; and that at the receiving set this radio-carried current may be translated into sound by "headphones," or into pictures by a radio camera.

The whole apparatus is, therefore, comparable to a long camera with a lens in Washington and its photographic plate in Boston, with this difference, that the one lens in Washington may put its picture on ten, one hundred, or one thousand photographic plates in as many different cities at the same time, and at distances limited only by the radio power of the broadcasting station.

There are the same plates and plateholders, the same lens, but there are miles instead of inches between lens and plates. And because there are intervening obstructions, radio instead of light is employed to carry the image from lens to plate.

This simplicity and flexibility readily lends itself to many useful purposes in industry. Of these one naturally thinks first of pictures for news illustration of telegraphic text in the daily paper. But it is more



THE RADIO VISION MACHINE

This laboratory model extends vision as far as radio will carry speech.

probable that the transmission of radio photo news copy will be the most useful service, for this method overcomes time, distance, isolation, storms and breakdowns of the usual means of communication; and serves a thousand daily papers at no more expense than service to a single patron. Nor does radio interference and "static" prevent the reception of perfectly readable copy. A hundred words a minute from typewritten copy is an every day attainment already, and one thousand words per minute soon is confidently predicted.

As some seventy odd of the great newspapers of the country already have radio broadcasting stations, attaching these simple prism-ring radio-photo sending-and-receiving instruments would insure the papers against interruption of news surface by the breakdown of present telegraph lines, if indeed they did not find it a better and faster means of exchanging news with each other; as well as service to papers which have no broadcast station but install a radio-photo-news-receiving camera.

Transmitting messages by reducing the words to letters and each letter to dots-and-dashes, and at the receiving end decoding these dots-and-dashes into letters and words, right enough in 1840, seems terribly antiquated today. Photography is the most rapid means of copying anything, and radio the swiftest in travel. The two have been combined to give a better means of communication.

Radio messages in facsimile of handwriting, signature and explanatory sketch not only can be sent in speed competition with the dot-and-dash telegraph, but they have unusual tactical value to the Navy and Army, for this is the only method of radio communication which may carry its own authentification by the addition of the autographic signature of the sender.

In all schemes for sending photos by wire with cylinder machines, the picture is traversed in a spiral line until the whole surface is covered. But from a line picture a good half-tone plate for use in a newspaper cannot be made with the regular half-tone equipment. Efforts have, therefore, been directed toward a radio-photograph in which no lines would appear. By the use of the prismatic ring, success has been attained. Not only can good half-tone plates be made from these photographs, but art work can be done upon them to make the photo more contrasty in parts, if so needed for newspaper illustration.

A stationary picture surface is employed with the prismatic plates and the pictures are made by moving a pencil of light over the picture very much like the artist does when he tacks a paper to an easel, and works with his crayon. With the cylinder scheme the pencil is held stationary, the picture surface moving under it. It is in this way that the light values of a "still" photograph are converted into electrical values at the broadcasting station; and at the receiving station changed back again into picture characteristics, a faithful copy of the original distant photograph. As animated pictures differ from "still" pictures only in the speed of presentation, it is obvious that having attained a high quality in photographs by radio, then, to get radio vision, speed is the only remaining problem to be solved.

The solution of the speed problem was attained by substituting for the "fast" plates of the prismatic photo machines, a rotating disc, carrying a plurality of like lenses, to draw the lines.

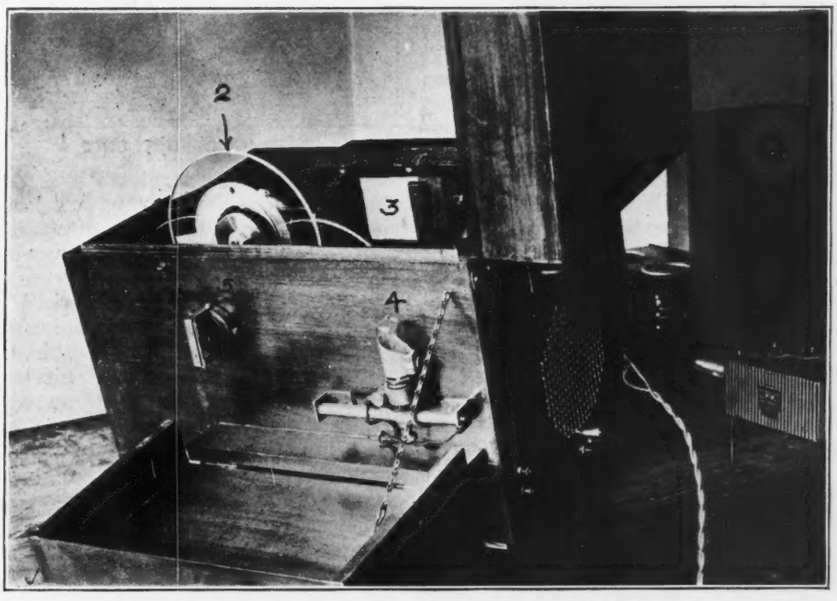
The lens disc is located in front of the same "slow" plates used in the radio-photo machines, and is properly geared to these prismatic plates to give the required number of lines per inch of picture surface. The mechanism is then speeded up until the pictures are reproduced, on a ground glass screen in the receiving machine at a rate of ten pictures per second.

It has been found that ten pictures per second in a radio vision machine, which has no light-interrupting shutter, gives as smooth continuity as the usual sixteen pictures per second of the theatre motion picture projector where a 50-50 shutter cuts off the light half the time. This is because persistence of vision is not the result of frequency of retinal impression alone, but of frequency and light intensity combined. If you doubt it, glance just once at the noon-day sun.

The telescope enables us to see to great distances, but only along straight lines; and as straight lines only lead away off into space, the telescope is limited to a study of the stars. However radio vision enables one to see along curved lines. Therefore, one may see around obstructions, over mountains, perhaps ultimately around the earth. Radio vision is right now a matter of daily laboratory demonstration.

From the very nature of the invention it would seem that in the homes radio vision would ultimately find its greatest usefulness, for not only would pictures for news and for entertainment be received, but music as well. An entire opera might thus be enjoyed through both ear and eye, as all the family, old and young, listens in and looks on amid the comforts of the home fireside.

The latter feature is a new achievement which permits sending two or more messages from the same broadcast station on a single wave length, the picture at radio frequencies, and the music at audio frequencies; to be received on the same receiving set tuned to this single radio frequency, the attachment for both vision and music costing less than the radio set; all to the entertainment and delight of a million boys and girls on the farms of America, unhindered by muddy roads or snow blockades.



THE RADIO PHOTO-RECEIVING CAMERA

The lid is raised to show (2) prismatic plates; (3) photographic plateholder on far side of camera; (4) small lamp, and (5) lens and mirror on near side.

THE VACUUM—THERE'S SOMETHING IN IT

(*Continued from page 95*)

remote disclosures as that distillation or evaporation of solids in vacua proceeds in straight lines. The electrical currents in poor vacua are best known in luminous Geissler tubes, Moore tubes and Claude tubes, as seen on the streets of Paris, for example. They are themselves a large subject, but I will consider later on, only one historically important experiment with them, the Hittorf experiment.

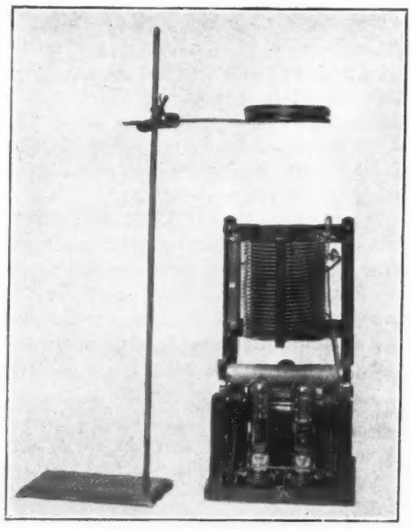
Electric currents through vacua, where gas is so completely removed that it has no appreciable action, are more strictly a part of my present paper. After the work by which the individual and indivisible negative electrical charge or electron was defined, it seemed quite fitting, though unexpected, to learn that these negative charges were exuded by hot bodies. The result of this disclosure formed the basis for most of the modern electrical phenomena in vacua. The activities of electrons are apparently the cause of most electrical and chemical processes. Their motions constitute electric currents and the currents are determined and controlled by voltage or potential differences.

Bees might illustrate electronics, though it's admittedly bad policy to push bees too hard. If bees represent electrons, then matter in general becomes the hives. When the hives are cold or in the dark the bees stay inside. Under the effect of heat or light the bees are induced to come out. Similarly highly heated matter, such as tungsten, exudes electrons, and at ordinary temperatures light induces electrons out of metallic potassium, for example.

What are the bees or electrons going to do after they are out of the hive (or the metal)? That depends on impulse or pressure. They will fly more or less directly in that special direction which tends to relieve that particular pressure. They proceed down the gradient. The electrons coming out of the metal (because of heat or light) will also fly in that special direction which will tend to relieve the particular electrical pressure. They also proceed down the gradient. But if there is no particular impulse or gradient both bees and electrons hang around the source.

A lot of electrons, like bees, flying in a common direction, becomes a current or cathode ray. We might let either of them fly from the hot or lighted spot into a cold or dark one and until we heated or lit up the latter they would not come out. This unidirectional current corresponds to what takes place in rectifiers and kenotrons where we have impulses in the two opposite directions but one hot and one cold electrode in vacua. If both hives (or both electrodes) are equal in temperature or illumination, no differential in current is possible, and with alternating impulses, instead of pulsating direct current passes. Thus bees illustrate two-electrode vacuum devices.

In the three-electrode vacuum tubes the third electrode is a sort of grid or open fence, located between the hot and cold electrodes. This grid lets electrons pass freely except when it is negatively charged. Thus also the bees would pass through a wire fence when they might be stopped if their impulse to proceed could be suddenly removed there. The negative charge is used in the three-element tube to alter the intention of the migrating bees or electrons as often as desired, and this with the rapidity of light.



HIGH FREQUENCY UNIT

In the case of "wireless" it is the impulse from the antenna or loop, changing with every delicate change of voice-current or code-current, which, when led to the grid, charges it and thus controls the currents within the receiving tube. These controlled currents do the work in the telephone.

Everybody knows that wireless tubes are very sensitive. One cat-power of electricity used in New York actually puts the impulses into a wireless outfit in San Francisco, and at the same time it also puts the identical impulses into millions of other receivers. But some appreciable energy must be used by each receiver to direct the local battery which operates the head sets. This minute quantity of energy has been made significant as follows:

If a house fly climbs up a window pane one inch he does a definite amount of work in lifting his body that much. If this work constituted the supply fed into the wireless tube from space it would suffice to continually actuate the outfit for a quarter of a century. This might interest a future student of telepathy, if the time comes to determine how far the energy of one thought may influence thought in a distant brain. It has not been possible thus far to determine the quantity of energy which is expanded in thought. Just keeping alive transfers so much energy into heat that the additional energy transferred when we think, has been too small to detect. But it need not be small compared to the power sensitivity of a wireless set.

Before showing the tubes I will briefly summarize them. The mere names of these modern applications of electrons in vacua are legion. The kenotron is a vacuum tube which changes high voltages alternating into direct current and it has its counterpart for low voltages in the battery-charging tungar rectifier and the mercury rectifier. The various radiotrons, receivers, and amplifiers of wireless are also the most direct applications of the action of negative electrons in good vacua. But X-ray tubes must also be considered in this connection, because X-rays are the result of the "bump," if you will, of rapidly moving electrons in vacua against the atoms of matter.

Electrons in motion are also directed and controlled by electromagnetic, as well as by electrostatic fields. Therefore the magnetron and axiotron have to be shown or referred to. Because the mere illumination of such metals as potassium (like the high heating of other metals, such as platinum and tungsten) causes them to emit electrons, the photo-electric cell has to be included in our illustrations.

The electrons within the vacuum, as in a wireless detector tube, obey the inconceivably feeble electrical impulses received by the antenna. Conversely, the motion of electrons set up impulses and waves in space. In other words, the vacuum detector may be made a wireless wave generator. They are used in most broadcasting stations.

The wave lengths of the magnetic waves produced by the changes of motion of the electrons are very long in case of wireless (say 100 to 10,000 feet), millions of times shorter in ordinary light and millions of times shorter still in X-rays, but they are all in the same medium and all due to motions of electrons.

The induction effect of currents themselves is nothing new. Motors and generators depend on it, but the production of very high frequency currents is a recent result of vacuum tube development and so is part of our subject.

Finally to give an impression of the distance such work has gone I have also added the case of a one-atom deep layer of thorium on tungsten in a vacuum and its effect on electron emission.

In order to illustrate several of these vacuum phenomena simultaneously, the Hewlett loud speaker is made part of this article. Microphonic currents are carried to one vacuum device or receiver and this acts in turn upon others as amplifiers. Telephone currents of large magnitude carrying the characteristics of the voice are thus produced and conducted through flat spiral coils close to and on both sides of a thin metal plate whose vibrating motion transfers to the air powerful sound waves corresponding to the original voice. This plate has to be subjected at the same time to induced currents from a direct current which is produced from the city alternating current by several vacuum kenotrons, as will be described.

Now for some experiments. The first great use of vacuum was in incandescent lamps. I burn out an ordinary tungsten lamp by raising its voltage very much above normal. It lasts for a few minutes only, but it gives a light perhaps five times as efficient as we usually see. The lamp dies because the tungsten vaporizes or melts. The vacuum is not at fault. It is because of these limitations that commercial lamps are so made that they burn at normal voltages on proper circuits an average of one thousand hours. If we were satisfied with a shorter life we could have a more efficient light, but experience has shown that we would be unwilling to submit to short life lamps in order to have the added efficiency. To lengthen the life of lamps much study has been made of distillation of metals in vacuum and of methods for returning the distilled metal to the filament. Much has also been done to make the deposit on the glass invisible or white so as not to interfere with light transmission. Naturally we are always on the lookout for metals, such as the newly discovered hafnium, which might possibly live longer as filament than tungsten now lives. Thirty or forty years of research work had been spent on high vacuum incandescent lamps before Dr. Langmuir showed us how to make still better lamps by putting back into the vacuum gases like argon and nitrogen.

When the material of a filament distills in vacua it does not meet interference to the motion of its molecules, and the distilling substance proceeds in straight lines from the heated source. This is often observed when an incandescent vacuum lamp arcs or burns out. Metal shadows of interior parts of the lamp are then often cast onto the walls. This is shown more clearly when a metal like gold is evaporated from the surface of a tungsten filament in vacuum. By interposing a design (in this case a star) the shadow in gold is cast on the glass. This simple phenomenon is mentioned because it fits in with the kinetic theory of gases and explains many things observed in vacua. The "mean free path" of molecules or atoms is very long in good vacua, and so straight line distillation occurs.

In the historic Hittorf experiment two vacuum bulbs, each carrying an electrode, were joined together by two glass tubes, one very short and one exceedingly long. When electric current was passed from one bulb to the other, it evidently chose the longer instead of the shorter path, because the longer tube became highly luminous, while the shorter one did not. This is a quality of electrical conduction in vacua where small quantities of gases still remain, but it cannot be gone into here.

The historic Edison effect was discussed and its relationship to pure thermionic currents shown. Where it was once thought that nearly visible particles of the filament were shot across the space between filament legs in vacua, now we recognize in very high vacua, only the unidirectional motion of negative electrons.

In vacuum tubes like the kenotron these electrons pass from the hot filament to an electrode commonly called the "plate." This pure emission current is the basis for the so-called rectifiers, because, only when the filament is negative, does any current flow across the space. When gases are present greater currents may be carried, because by the ionization of the gases, the moving electrons produce new conductors from the gas molecules. Thus the tungar rectifiers, containing a little argon, and the older mercury vapor rectifiers, involve the same principle. Without some gas present the negative electrons, by their very concentration, constitute a space charge which limits the current. This space charge is removed by the ions produced within the gas when present.

When we interpose a grid or wire screen between the hot filament and the plate of the two-electrode tube or rectifier, we have what we now so commonly use in wireless for receiving, for amplifying, and for production of high frequency currents. The discovery of the controlling or triggering action of the third or intermediate electrode was made by De Forest. A negative charge applied to this electrode or grid interrupts or modifies the electron stream, the current, from the hot filament to the plate. As it takes almost no energy to charge this grid (little more than a "token" of energy, voltage) the slight power from a wireless antenna in its fluctuation may be used to control or to trigger, or to let through corresponding jolts of greater energy, which are in turn supplied by some local battery. An ordinary incandescent lamp is lighted by current which is passing through a three-electrode tube from hot filament to plate. Its light indicates this current. The grid, or antenna wire, sticks up from the tube so that it can "pick up" electric charges from space. A small negative charge is produced on a rod of insulating material by merely rubbing it with a piece of paper. The charge so produced causes the lamp to go out, or light up, as the charged rod is brought near to or removed from the exposed end of the grid wire.

As the negatively charged grid cuts off the current of the three-element tube, so an external magnetic field will also do it in the two-element tube, by so influencing or directing the moving electrons that they cannot reach the plate. Such a device, called a magnetron, is shown. This particular magnetron, consisting of a cylindrical plate in a vacuum and a central filament within it, has a coil of wire wound on the outside of the glass. A feeble current is sent through the coil from a battery. A magnetic field produced within the coil by this current is intentionally made about equal to that of the earth's magnetic field, so that by moving the whole apparatus about in space (thereby at one time adding to the earth's field, at others opposing it), the magnitude and direction of the earth's magnetic field can be disclosed by a meter which indicated the resultant current. When the magnetron points towards the north pole, the meter shows no current, while in other positions currents were measured.

Another useful vacuum tube of this type is one in which the magnetic field of the filament current itself becomes great enough during each current cycle to deflect the electrons so that they will not reach the plate. By this tube, "the axiotron" the frequency of an alternating current may be doubled or direct current be changed into alternating.

Another vacuum tube is the photoelectric cell. One of these is shown connected with a relay to a lamp so that

when light shines upon the cell the burning electric lamp is extinguished, and is relighted on cutting off light from the photo-electric cell. In other words, it turns on the lights when it is dark, and turns them off when it is light. This depends on the fact that some metals, like potassium, emit electrons when light falls upon them. These electrons in vacua constitute a current when they are made to move by the electrical impulse. To repeat, applying potential to a vacuum tube having a potassium electrode and another electrode for leading off the current, causes current to flow in negative electrons from the illumined metal and this current actuates the electrical switch which turned off the lighting current of the burning lamp.

This leads to the next, an ambitious physiological experiment. A photo-electric cell is made to represent a crude "eye" which was connected to a so-called "nerve" leading to a "brain." The nerve was merely a long box having electrical capacities and suitable amplifiers or three-electrode tubes within. The capacities serve to slow down the apparent rate of flow of the feeble current from the artificial eye so that indicating lamps along the top of the box or "nerve" will light up, one after another, as the impulse from the "eye" passed along that path, or the nerve. After the last lamp is thus lighted by these amplified currents an electric bell rings to indicate reception at the "brain" end of the circuit. This is not a reliable replica of the real nervous system, but as an application of the vacuum tube which amplified the slight energy available and necessary for the experiment. With such slight energy it became practicable to show the delayed transmission and reception which is necessary for an illustration of nerve action. Nerve impulses travel much slower than electricity usually does, and this slow speed was one objection to visualizing nerves as electrical conductors until Crehore and Williams showed that nerves might be naturally so constructed as to transmit slowly.

In order to show another vacuum product (the X-ray tube) an effect of X-rays is described which is not usually thought of in connection with X-rays. Three rubber balloons, suspended close together by long cords, are first charged electrically. They then repel each other and stand stationary in space as at the corners of a large triangle. As soon, however, as a feeble beam of X-rays is projected towards them they quickly discharge and fall to their original position in contact with one another. X-rays ionize air or make it conducting so that the balloons could not retain their mutually repelling charges. This is the basis of a method for measuring the intensity of beams of X-rays.

References were made to the various applications of X-rays, as in the study of internal structure of crystalline chemical compounds and elements. Cathode rays, currents of negative ions in vacua when speeded up by high voltage, produce by their impact, X-rays which are characteristic of the material on which they impinge; one may say characteristic of the mass of the atom of the substance of the target. It is through this fact that the X-ray spectra of the elements considered as to wave lengths are arranged in the same order as the atomic masses in the periodic table of Mendelejeff, and by this very method the newest known element, hafnium, has been recently added to the known metals. Referring again to our bee analogy, let a fast flying swarm strike bells so hard that they make them ring. From the sound or musical notes we guess roughly the sizes of the bells. We could thus place them in their musical series. The sound corresponds to the X-rays produced when the bees are electrons of cathode rays and sound waves are ether waves. The mass of the bell is disclosed by the tone or frequency; the mass of the atom, by the same sign, is disclosed by the ether wave-frequency. When a certain mineral was used as a surface for the electrons to hit, a new musical note in the ether was found. It was recorded photographically. Its place in the scale of elements had been predicted as accurately as middle C on the piano might have been predicted if it had never been heard.

With higher voltages the velocity of the cathode rays (or electrons) always increases. In the X-rays thus far produced, however, the penetration or transparency is practically limited to about a quarter of an inch of lead. It is interesting to note that the similar rays from radium, the so-called gamma rays, can penetrate nearly a foot of lead. This corresponds to an exceedingly high electro-motive force. Thus radium rays (gamma rays) might be made in vacuum X-ray tubes if millions of volts were applied.

An apparatus is shown, devised by Dr. Hull, which is essentially a two-electrode vacuum tube, the hot tungsten filament has a little thorium in it. At a certain very high temperature this thorium rapidly diffuses to the filament surface. This thorium surface then has the peculiar power of emitting electrons a hundred thousand times as rapidly as pure tungsten at the same temperature. An ordinary lamp was lighted in this experiment by letting this thorium electron emission current flow through the lamp filament. The vacuum tube containing the thorium-coated tungsten also contained a little gas. When the lighted lamp was short-circuited for an instant by a switch the potential on the vacuum tube was thereby greatly increased, and this caused positive ion bombardment of the filament and thus tore the thorium all off of the tungsten surface, so that very few electrons were being emitted, *i.e.*, those characteristic of pure tungsten at that temperature. Then the load (the lamp) could no longer be "carried" by the electron current. To repeat, the heavy positively charged gas ions under the impulse of the raised electrical potential act like a powerful sand blast and effectively clean the thorium from the tungsten, thus greatly reducing the emission current. By highly reheating the filament for a few seconds only, a fresh layer of thorium diffused anew to the surface of the filament from within the tungsten, so that then at the previous lower temperature the load or lighting current for the lamp was carried as before by electrons emitted from the thorium surface. This is mentioned as a proof of the production of a layer of thorium on the tungsten only one atom deep. The electron current from thorium on tungsten is greater than from pure tungsten and also than pure or massive thorium and is maximum when the single atom layer is present. This is confirmed by experiments on partial recovery of the surface and supported by thousands of successive repetitions of this experiment on one filament.

The production of high frequency current by means of pliotrons was shown and an ordinary incandescent lamp was lighted by being brought within a foot of a coil which was carrying the current of several million cycles. This was said to be about as near to wireless transmission of power as we now have. This high frequency principle is also being used by Professor Northrup of Princeton for special electric furnaces. In these, the induced currents in the material of the crucibles or the material to be heated generate high temperature through local resistance.

The loud speaker devised by Dr. Hewlett consists of a 26-in. flat conducting disc in a magnetic field. The vibrations of the disc corresponding to the voice currents produced the sound waves without the intervention of a horn. The use of vacuum tubes in this device consisted in the following:

A microphone is placed near the speaker and the sound waves of his voice causes to be generated in this

(*Continued on page 120*)

As a football player he's a good poet

LET'S admit that all men are not born for gridiron honors, just as all men are not born poets.

You can admire a man's grit for plugging away at the thing that comes hardest to him. He does derive benefit in developing himself where he is weakest. But to achieve real success it is only common wisdom to pick out the line for which you have a natural aptitude—and go to it.

Particularly if you are a freshman it may be useful to remind you of this principle, because it can help you start off on the right foot in both your campus activities and your college courses.

If your fingers love the feel of a pencil, why not obey that impulse and come out for the publications? You can serve Alma Mater and yourself better as a first-class editor than a third-class halfback.

Similarly, when it comes to electing your college courses, you will be happier and more efficient if you choose in accordance with your natural aptitude.

The world needs many types of men. Find your line, and your college course will be a preparation for a greater success.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

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ENGINEERING AND EXPLOSIVES

(*Continued from page 93*)

involving especially hard drilling. What this speed means may be realized from a study of the aqueduct built by the Roman Emperor Claudius in the first century to conduct the waters of Lake Fucinus 50 miles across hill and valley until it reached the gates of the Imperial City. That aqueduct was considered as ranking foremost among Roman engineering undertakings. Included in the project was a single tunnel three and one-half miles long beneath Monte Silviano which required the labor of 30,000 men for eleven years.

In further comparison, it might be pointed out that in modern times, but before the powerful dynamites now in use were available, the Nesquehoning Tunnel at Carbondale, Pa., was constructed. This tunnel pierces Locust Mountain. It is 16 feet wide and 19 feet high. Its length is 3,805 feet. Black blasting powder was used in this case and on one heading, an average penetration of 80 feet per month was obtained, and on another heading, 105 feet per month. On the Shandaken Tunnel job, 620 feet were excavated in one calendar month. This gives some idea of the increased efficiency of modern explosives and engineering practice.

According to Ulen & Company, the builders of the Shandaken Tunnel, two methods of attacking the headings were employed. In good rock, the top heading and bench method could be used, which permitted two shots per day. The top heading was drilled with four water Leyner drills on vertical columns, two per column, the bench being drilled with jackhammer drills. On the average, twenty-eight holes were required in the heading and eight in the bench. But where timbering had to be carried close to the face in bad rock, the full face heading method was used, in which six Leyner drills were mounted, three on each vertical column. In this type of heading about thirty-four holes were drilled and, using the swing shift, progress was equivalent to a shot and one-half a day. During the excavations carried on in 1921, the average pull per shot was 8.1 feet, but in 1922 this average was increased to 9.2 feet.

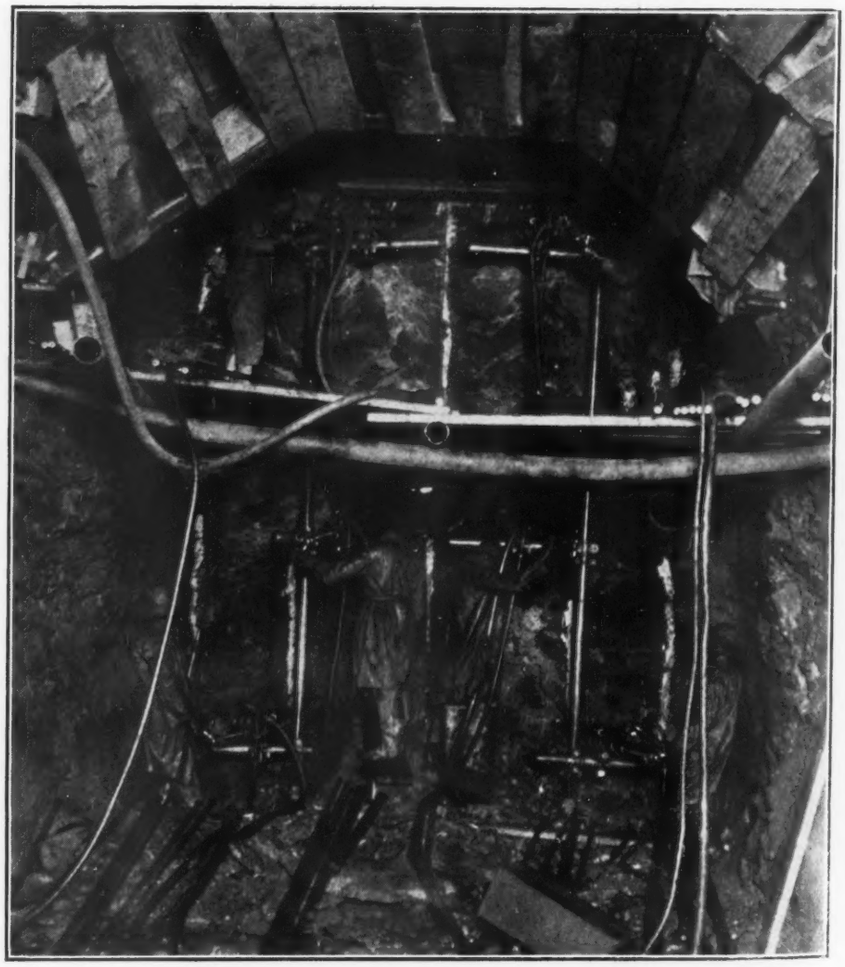
Another interesting construction project for which explosives are being used in large quantities, is the damming of the Dix River at Burgin, Kentucky, where it flows between vertical limestone cliffs, 300 feet high. The purpose is to supply hydro-electric power for the near-by coal fields and for the lighting plants and street railways of the towns in this region. The dam is to be constructed of broken rock with concrete facing, the whole rock fill requiring 1,500,000 cubic yards. The explosives engineer who was consulted suggested blasting a portion of the cliff directly into the river bed, thus placing a large yardage of rock at the dam site. When this shot is fired it is estimated that it will throw 25,000 cubic yards of rock from the cliff into the bed of the river to start the rockfill for the dam. For the completion of this whole Dix River project — diversion tunnel, "coyote shooting" and quarrying — at least half a million pounds of dynamite will be used.

The allowable space does not permit a more detailed description of the many interesting and often novel engineering problems incident to the preparation and detonation of the explosive charges in blasting operations such as those above outlined.

Explosives are being employed in large quantities in building the new roads throughout the country which are doing so much to facilitate traffic and transportation, the average being about 1,000 pounds per mile of highway. These explosives are used in quarrying the stone, and clearing and draining the right of way. Engineers, particularly in the southern states, are using dynamite in increasing quantities to excavate ditches to drain low land and reclaim large areas of marshy ground.

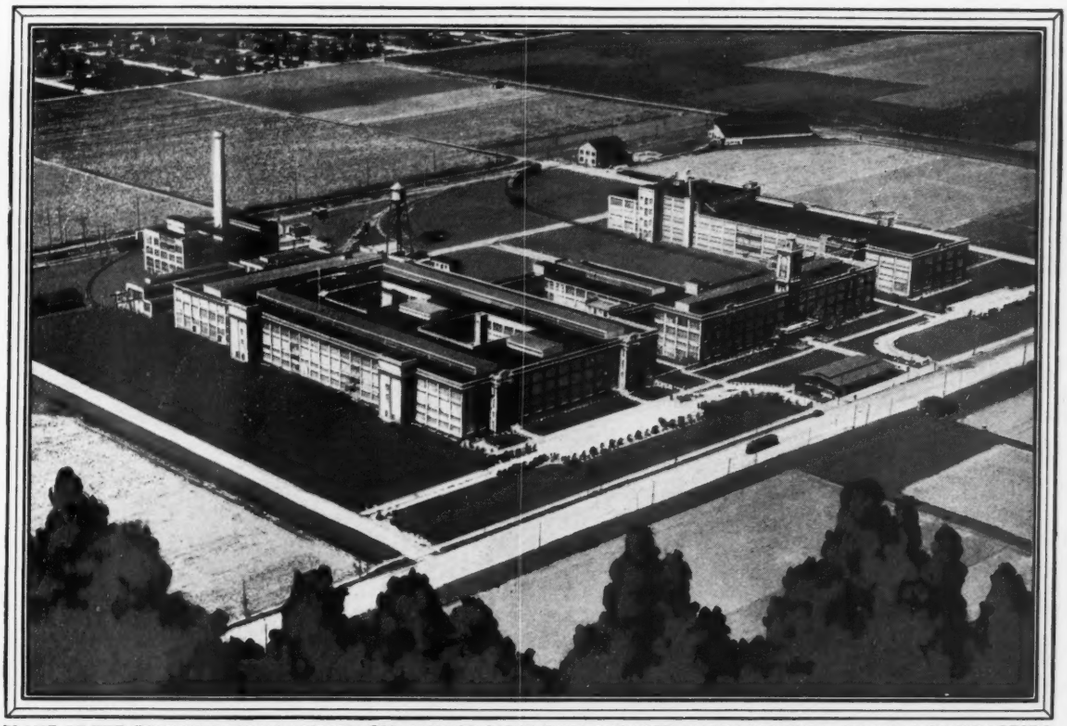
Dynamite is being used more and more generally for demolishing old buildings, stacks, walls and foundations. Explosives have been used to great advantage in preventing flood damage resulting from ice jams and gorges in streams and rivers. Dynamite placed under ice in such cases

(*Continued on page 126*)



DRIVING THE SHANDAKEN TUNNEL

In this section of the tunnel, the full face heading method was used with six Leyner pneumatic drills, mounted on two 14-foot columns, two operated from the platform and four below it.



PLANT OF THE GOODYEAR TIRE & RUBBER COMPANY OF CALIFORNIA, LOCATED AT LOS ANGELES. GENERAL CONTRACTORS: HUNKIN CONKEY CO., CLEVELAND. PLUMBING CONTRACTORS: ARTHUR HESS, LOS ANGELES, AND H. E. TRYDAY, LOS ANGELES

THE ARTERIES OF A MODERN FACTORY

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They make possible the centralizing of the production of power, heat and gas at efficient large-capacity plants. They allow the isolation of fire hazards and obnoxious processes.

Should one of them fail, however, production might be crippled, even stopped. That is why it is so important to get uniform quality in every part of a piping installation; why the Crane name, the assurance of dependable quality on products that cover all piping needs, means so much to architects, engineers and owners.

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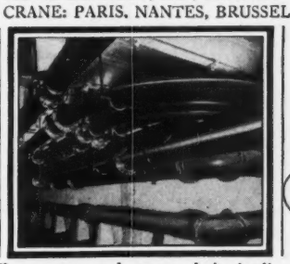

All steam, water and compressed air pipe-lines in the Goodyear plant are Crane materials

BURNING HEAVY FUEL OIL IN DIESEL ENGINES

(*Continued from page 104*)

It was gratifying to find that the surfaces of the various heating coils were in desired proportion and of proper size and that no alteration whatever was necessary to obtain the desired result. Not only did the heating system for the fuel oil function very satisfactorily, but also the engine proper. There did not seem to be any difference whatsoever whether light or heavy fuel oil was used, so far as the operation of the engine was concerned. The engine was thoroughly inspected at the end of the test and the cylinder liners were found well lubricated and highly polished. The tops of all pistons were free of carbon and none of the piston rings were gummed up, while the cylinder heads and exhaust valves were in good condition as found in Diesel engines when operated on light fuel oils with clear exhaust.

It may be mentioned that it was necessary just before stopping the engine to change the fuel from heavy to lighter oil. This was done to clean the fuel pump and pipes of heavy fuel oil and to dispel the exhaust gases of the heavy fuel oil from the exhaust pipes. If this is not done, then the moisture in the exhaust gases, after the engine has been stopped, will condense and unite with the sulphur dioxide contained in the exhaust gases, forming sulphuric acid, which would cause a heavy corrosion of the exhaust pipes.

The engine was started with light oil from the overhead tank, passing through the filter into the fuel pump, while the heavy fuel was being heated. It took from one-half to three-quarters of an hour, depending on the temperature at the test stand, to heat the whole system, after which the fuel was changed from light to heavy fuel oil.

While the engine could be easily and successfully operated under fluctuating loads down to no load, with perfectly clear exhaust, it should be mentioned that a continuous run without any load was not altogether satisfactory, after the temperature of the combustion chambers corresponded to no load. These conditions, however, were improved after the compression was temporarily raised from the normal (475 lbs. to 530 lbs.). There was no difficulty in always obtaining perfectly clear exhaust when the engine was operated with normal compression and when running at quarter load.

The splendid results obtained with the heavy fuel oil were to a great extent due to proper functioning of the fuel oil heating system, the proper selection of the injection pressure, atomizer plates, atomizer nozzle and some other refinements of the Fulton-Diesel. It may be stated that the atomizers of the Fulton-Diesel follows, in general, conventional lines; that is, the fuel is discharged and evenly distributed on perforated atomizer plates and the injection air forces, rather than syphons, the fuel through these plates and nozzle into the combustion chamber.

The tests referred to proved that smaller Diesel engines as well as large ones can burn successfully, heavy fuel oil, even at fluctuating loads, provided they are properly designed and equipped with a suitable fuel oil heating system. It should not be inferred that all small engines built at present will handle heavy fuel oil. Unless the engine is built to burn heavy fuel oils successfully, and actually does so with perfectly clear exhaust, it is not advisable to use heavy fuel oil, as the savings would be more than counterbalanced by increased maintenance cost and frequent shutdowns.

Technology Branch, H. C. S.

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TECHNOLOGY BRANCH, H. C. S.

76 MASSACHUSETTS AVENUE

CAMBRIDGE, MASS.

QUARRYING—
Ancient and Modern

THE quarrying of stone reaches back into the twilight of antiquity. It was practiced by peoples whose only records are written in their crumbling temples and weather-worn monoliths. From earliest times stone-cutting has been a well-understood art.

Quarrying today is an important industry. Stone finds a thousand uses in our complex industrial structure. And in stone, architectural genius creates its most eloquent expression.

But the modern quarryman has at his disposal a force undreamed of by the ancients. Explosives have taken the place of arduous hand labor. Now, whole hillsides are blasted almost as easily as one block could be cut by hand tools alone.

Quarrying methods vary with the specific problem at hand. The quality and condition of the stone, the purpose for which it is to be used, and the general quarry conditions determine the type of explosives to be employed.

Du Pont manufactures an extensive line of explosives. Among those recommended for quarrying are: Red Cross Extra or du Pont Extra; Du Pont Straight Nitroglycerin; Red Cross, Du Pont, Repauno and Forcite Gelatins; Arctic Special. Also Du Pont R. R. P.—a "low powder" of granular formation.

The du Pont Company manufactures the proper explosive to do each type of blasting best, at least expense.

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Explosives Department : : Wilmington, Delaware

DU PONT
EXPLOSIVES

One Thing You
Will Learn—

Now or Later?

THE real leaders in the professions and in industry serve for reasons other than profit. Pride in knowledge or in craftsmanship is not satisfied by mere gain. New points in the progress of civilization are established first by those who devote themselves to a product rather than to a price.

THE BUNTING BRASS AND BRONZE COMPANY
TOLEDO, OHIO

Branches and warehouses at New York, Chicago, Cleveland, Philadelphia, San Francisco, Boston

BUNTING BUSHING BEARINGS
PATENTED

THE VACUUM—THERE'S SOMETHING IN IT

(*Continued from page 114*)

microphone feeble electromotive forces which are applied to the grid of a pliotron. These feeble electromotive forces cause relatively large variations in the electric current flowing between filament and plate, which in turn are used to secure larger electromotive forces to be applied to the grid of another pliotron. By the use of several amplifying pliotrons the original feeble electrical currents are multiplied several thousand times and supplied to the loud speaker, which reproduced the original sounds with many times the original volume and great faithfulness of quality. To operate this amplifier of pliotrons requires a direct current of several hundred volts. This was obtained by first transforming the power from the ordinary alternating current lighting circuit to a relatively high voltage, next rectifying this high voltage alternating current by means of kenotrons, and finally smoothing out this pulsating current by means of appropriate electric circuits.

The high degree of faithfulness of reproduction realized in this loud speaker is due partly to the absence of a horn, eliminating horn resonance (one of the usual sources of distortion in a speech reproducer), and partly to the method of vibrating the diaphragm by forces which are distributed fairly uniformly over its surface, instead of being acted upon in a very limited region, as is the case in most other loud speakers. This feature eliminates rattling and ringing of the diaphragm or the production of high overtones by the diaphragm vibrating in its partial modes.

Delaware River Bridge Progresses. The stringing of the cable wires on the Delaware River Bridge has been begun following the completion of the footbridges. The handrails for the footbridges were completed in August and the haulage ropes were erected complete and ready for operation at the same time. During the past two weeks the eight wires that will serve as guide wires have been pulled across the river and adjusted to correct sag, and the operation of wire stringing is well under way. The contractors schedule for this work provides that the haulage ropes shall make the trip across the river from anchorage to anchorage in about nine minutes. About ninety-seven per cent of the wire required has been produced at the wire drawing plant.—*Engineers and Engineering.*

Radio Signals Strengthened by Cold Waves. Cold waves affect radio transmission, according to recent observations taken at the Bureau of Standards in Washington, on daylight signals from the long-wave transatlantic stations at New Brunswick and Tuckerton, N. J. The signal strength was found to be quite uniform during most of the year, but with the coming of the cold waves of January, 1924, the signals rose to more than twice their normal strength. At the same time there were deviations of many degrees in the apparent directions of the sending stations, as indicated by the radio compass, even in the forenoon when long-wave compass bearings are generally free from errors.

The end of the series of cold waves in January did not at once restore transmission conditions to the uniformity of autumn and early winter but left a condition of instability which persisted through the comparatively mild cold of February and early March. During this time the signals frequently fluctuated, going to high values for a few hours and then returning to normal without any obvious connection with weather conditions.

There is at present no definite explanation of this phenomenon. The cause is evidently atmospheric and the connection with the cold waves suggests that either the part of the atmosphere concerned with the signal variations lies much below the Heaviside layer (80 or 100 km.) or that weather phenomena are correlated with atmospheric action at much greater heights than has been hitherto supposed.

Gasoline Quality Slightly Better. The tenth semiannual motor gasoline survey just completed by the Department of the Interior indicates that, on the whole, a better grade of gasoline is now being marketed than at the same time a year ago. Of the 146 samples of gasoline collected by the government in ten cities, 76 failed to meet in one or more points the Federal Government specification for gasoline. In the midsummer survey of 1923, 109 out of 158 samples failed to meet these specifications. A contrast of the 1923 and 1924 figures bears out the fact that the 1924 gasoline averages a better grade than the 1923 product.

ESTABLISHED 1870 INCORPORATED 1890

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MANUFACTURING COMPANY

Textile Soaps

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Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS 88 Broad Street, Boston 9, Mass.

What Engineering Owes to the Imagination

From An Argument Over Watches Came KDKA

BACK in the days when wireless was just beginning to spread, Frank Conrad (now Assistant Chief Engineer of the Westinghouse Electric & Manufacturing Company) and another official, happened to compare watches, to see if it was time to go back to work. Their watches differed.

Unable to convince his friend that his watch was right, Mr. Conrad suddenly remembered that the naval station at Arlington, Va., had just inaugurated a system for sending out daily time signals by radio. Just the thing to prove his point!

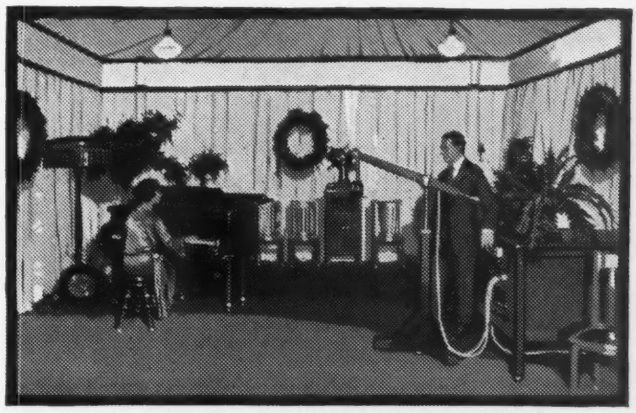
So he built a simple set of receiving apparatus, erected an aerial, and—you can imagine what happened! He was badly bitten by the radio bug. After proving to his satisfaction the accuracy of his watch, he started experimenting with the transmission of music by radio, with good success.

He began sending out phonograph music from his home, and attracted the attention of some of the big department stores, that had installed radio departments. They in turn, started advertising Mr. Conrad's "musical evenings."

Then, one day, upon arriving at his desk, he was summoned to the office of Harry Phillips Davis, Vice President of the company.

"Frank," said Mr. Davis, "I'm going to close your radio station." His attention had been attracted the night before to a simple note in a full-page advertisement, which read, "Mr. Conrad will send out phonograph music this evening."

You know the rest. In November, 1920, "KDKA" was formally opened to send out election returns. It had received the first license issued by Uncle Sam. Today over 500 broadcasting stations entertain and educate millions of people each night, a wonderful result from so insignificant an argument as one over watches.



Broadcasting Studio at Station KDKA, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa

Westinghouse

ACHIEVEMENT & OPPORTUNITY

WESTINGHOUSE ELECTRIC

FLAT GLASS

(*Continued from page 100*)

inch or two above the surface of the molten glass, just inside the edges of the drawing pot. These knurled rolls engage the sheet for about two inches on each side and serve to sustain it at a constant predetermined width. These edges are thicker than the intervening sheet of glass. The real pulling of the sheet is accomplished by engaging the outer edges of the sheet — after it passes over the bending roll—between the flattening table and a series of grip bars running in the same direction and placed just above the flattening table.

The lehr is provided with two hundred power driven rolls, covered with asbestos composition, over which the glass passes in continuous sheet form, emerging at the end onto a movable cutting table. Here it is cut into sheets of suitable size, dipped in a hot solution of hydrochloric acid and then distributed to the several cutting stalls. Experienced cutters then carefully select sheets, grade them and cut them into commercial sizes. These are packed with straw in boxes each containing fifty square feet of glass, regardless of the size of the sheets.

Sheet glass made by this process is absolutely flat, of uniform thickness, and is free from the distortions so common and annoying in all glass made by either the hand process or the cylinder machine process. It thus reaches the user with a natural fire finish, and without the defects inherent in glass made by the flattening or ironing out methods, employed by all other processes.

The machine will make glass from 1/24 of an inch to 5/16 of an inch thick, the thickness being governed by the temperature of the glass in the drawing pot and the speed of the machine which varies from twenty-five to one hundred inches a minute, according to the thickness of the sheet being pulled. The capacity of one machine is six hundred fifty-foot boxes of single strength glass in twenty-four hours.

It can readily be seen that the Libbey-Owens process of making sheet glass is practically automatic and eliminates the greater part of the strenuous, exhausting and nerve-racking labor so common in the manufacture of most articles of glass. It has therefore proved a boon to the artisans who produce the flat glass that plays such an important part in the life of every community.

Professor R. E. Danforth, of Rutgers College, has said in the *Scientific Monthly*: "The great change in home life and the change in industrial life, and in the industries themselves could not begin until an abundance of cheap glass filled all homes with a flood of daylight, and all shops and offices and factories, as well, keeping in the artificial heat at the same time. A host of new industries sprang into being in the wake of window glass, and these begat other industries, scientific inventions and discoveries, with magic rapidity. The general use of window glass is a thing of yesterday, and in its train there now follows a striking pageant of industrial revolutions, large factories were made possible, big business began, and the physical conditions of home life were completely changed."

So window glass has brought control of the weather, and controlled weather means continuity of effort in labor and inventions, which means production on the modern scale. Nor is this control confined to buildings. Portholes of ships, windows of railway cars, the glazed bodies of automobiles, all furnish shelter, warmth and light to keep men well and comfortable while going about the business of the world.

Electric Power in the Oil Fields. The California oil fields are practically completely electrified. The gasoline engine which formerly provided the great bulk of the power for the drilling and pumping operations has been largely replaced by the electric motor. This is due to the proven efficient and economical operation of electric motors over the older methods. The first oil well motors were used in July, 1910. Since then the change from the old engine drive has been almost complete. In the fields where decreasing production has made economy of production a deciding factor in the life of the wells this is especially true. The most important use of electric power is in drilling and pumping wells, but it is being used extensively for water pumps, gathering and line pumps, vacuum pumps, compressors, and circulating pumps. Also for dehydrators, arc welding, general lighting and to furnish power for machine shops.—*Journal of Electricity.*

W. A. WOOD COMPANY
Established 1868
373 ATLANTIC AVENUE, BOSTON, MASS.
"The Right Oil for the Right Place"
With more than a half century of practical experience in adjusting oils to the special conditions under which they are to be used in individual plants.
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Lubricating Oils and Greases for all purposes Perfection Motor Oils

LUFKIN TAPES—RULES TOOLS
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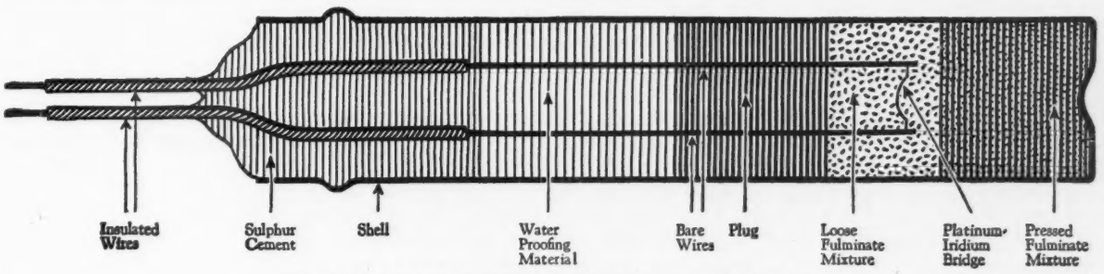

SECTION OF A HERCULES ELECTRIC BLASTING CAP
Showing the delicate platinum-iridium bridge wire in place

The Economy of Care

IMPORTANT CHECK WITH X-RAY

A long exposure is required to penetrate through the copper shell and the charge, to reveal the bridge wire (little more than one-thousanth of an inch in diameter) which is lost in this printed reproduction. But accurate adjustment of this tiny filament is essential to proper detonation.

ALL Hercules blasting caps and electric blasting caps are manufactured under careful supervision and inspection. This takes many forms, ranging from simple visual examinations by inspectors responsible for various steps in the process, to complicated laboratory checks under the direction of skilled chemists.

Samples from each day's output are subjected to numerous tests, in most of which the detonators are shot. The results tell the story of each cap shot, but if they are not normal, the reason for the abnormality may not be evident, and the evidence is destroyed by the test.

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ANOTHER X-RAY TEST

A shorter exposure which shows the wires correctly placed, and which would disclose any obvious faults in manufacture. Other tests in which we shoot the caps, destroy the evidence; the X-Ray gives a true picture of the cap's internal condition

HERCULES POWDER COMPANY

Allentown, Pa.
Birmingham, Ala.
Buffalo, N. Y.
Chattanooga, Tenn.
Chicago, Ill.
Denver, Colo.
Duluth, Minn.
Hazleton, Pa.
Huntington, W. Va.
Joplin, Mo.
Los Angeles, Calif.
Louisville, Ky.
New York City
Norristown, Pa.
Pittsburg, Kan.
Pittsburgh, Pa.
Pottsville, Pa.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
Wilkes-Barre, Pa.
Wilmington, Del.

FLAT GLASS

(*Continued from page 100*)

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All of Superior Quality and of Interest to Every Progressive Engineer
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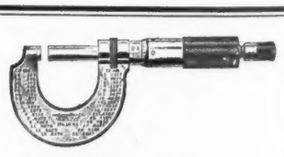
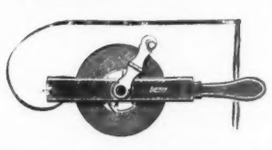

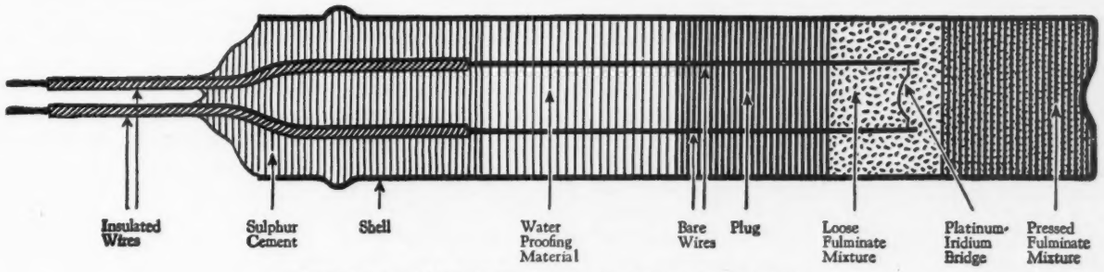

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Joplin, Mo.
Los Angeles, Calif.

Louisville, Ky.
New York City
Norristown, Pa.
Pittsburg, Kan.
Pittsburgh, Pa.
Pottsville, Pa.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
Wilkes-Barre, Pa.
Wilmington, Del.

HIGH PRESSURE STEAM AT WEYMOUTH

(*Continued from page 103*)

erator to the main bus and exhaust steam will be delivered through the reheater to the 350-pound steam system, where it will be used for generating additional power in the main turbo-generators. The output of the 1,200-pound boiler will generate about 3,000 kilowatts in the high pressure turbine and 12,000 kilowatts in the normal pressure turbines.

From the point of view of economy, the high pressure and normal pressure parts of the Weymouth station have been laid out to carry the base and peak loads respectively with the maximum overall economy in each case. For the peak load which forms the larger part of the station output, a normal pressure of 350 pounds has been selected as combining the best operating efficiency and the most economical use of capital, considering the character of the service. For the base load plant, which can be operated at high output throughout the year, the high pressure system was selected as giving an increase in efficiency which justifies its more complicated equipment. It should be kept in mind, therefore, that the high pressure plant is not an isolated unit but is a powerful part of the generating system, especially adapted to operate in conjunction with the normal pressure equipment to give the highest commercial efficiencies.

The Weymouth plant, in which this high pressure unit is being installed is being built by Stone & Webster, Inc., of Boston.

Railroad Truck Service Doubled. The Pennsylvania Railroad has doubled its truck service within the past few months, operating at the present time twenty motor units. They are used to replace local freight trains which were previously operated for less-than-carload freight. The State of New Jersey is completely motorized for this class of freight by the Pennsylvania System.

EVERY engineer should know APOLLO Best Bloom and Apollo-Keystone Galvanized Sheets, American Bessemer and Open Hearth Steel Sheets; and KEYSTONE Copper Steel

Rust-resisting Black and Galvanized

SHEETS

We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—Black Sheets, Galvanized Sheets, Corrugated Sheets, Formed Roofing and Siding Products, Galvanized Tank, Culvert and Flume Stock, Special Sheets for stamping, Stove and Range Sheets, Automobile Sheets, Electrical Sheets, Roofing Tin Plates, Bright Tin Plates, Black Plate, Etc. Sold by leading metal merchants. KEYSTONE quality is of particular interest to you. Send for booklet.

AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.

Founded 1878 — Incorporated 1884

OKONITE

TRADE MARK.

The Standard for Rubber Insulation

FOR 45 years the name "Okonite" has stood for the highest quality of Electrical Insulation for Wires and Cables.

"Okonite" itself is a rubber compound never containing less than 30% by weight [over 60% by volume] of high grade Para Rubber with absolutely no admixtures or substitutes.

All products bearing the Okonite trademark carry with them our unconditional guarantee of excellence and unvarying reliability.

Okonite is made in but one grade.

THE OKONITE CO., Passaic, N. J.

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AGENTS

Central Electric Co., Chicago, Ill. The F. D. Lawrence Electric Co., Cincinnati, Ohio
Pettingell-Andrews Co., Boston, Mass. Novelty Electric Co., Philadelphia, Pa.
Canadian Representative: Engineering Materials, Ltd. Montreal

VAC-M Arresters Will Protect Fire Alarm Apparatus

against lightning and other electrical disturbances.

Here's what a chief who has them in service has to say:

"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

The National Electric Specialty Co.

Toledo, Ohio

DAYLIGHT ILLUMINATION.

The angle of refraction being equal to the angle of incident, it is a simple matter to determine the correct angles to use in manufacturing glass which will give good illumination. But for proper industrial plant illumination, there is more to be considered than mere deflection of light. The direct beam of light must be eliminated in order to prevent sun glare, which is objectionable on account of its causing heavy shadows and strong contrasts which decrease the efficiency of employees and necessitate the use of shades which in turn reduce the light to such an extent that daylight illumination any distance from the light source is not sufficient. Therefore, in order to produce a glass which when used in the windows of industrial plants will produce as near to ideal illumination as possible, we must first eliminate the direct rays of the sun by deflecting the light to the ceiling and side walls which re-deflect it back to a distance 25 to 50 feet from the window throughout the entire working area. To accomplish this we have scientifically designed a type of glass which is named "Factrolite."

Factrolite consists of 30 ribs to the inch, running at right angles, forming 900 pyramidical prisms or 3,600 light deflecting surfaces which completely disintegrate the direct beam of light from the sun. Furthermore, the depressions in the surface of Factrolite are so slight that the accumulation of dirt and dust is minimized and can be perfectly cleaned with an ordinary dry scrubbing brush. Incidentally, the cleaning of windows is most important for keeping up production and increasing the efficiency of any industrial plant and should be given more consideration in plant management.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

Better Gears and More of them

TO give high quality, silent running gears in large quantities, Brown & Sharpe have developed two Gear Hobbing Machines—the No. 34 for spur gears only and the No. 44 for spur and spiral gears.

These machines meet the most exacting requirements of modern gear users and are particularly well adapted to automotive work where they accurately and economically are used to cut transmission and timing gears.

In order that you may appreciate the mechanical features of these machines, we have prepared a booklet which gives many of the advantages you can secure by their use. A copy will be gladly sent to you upon request.

BROWN & SHARPE MFG. CO.
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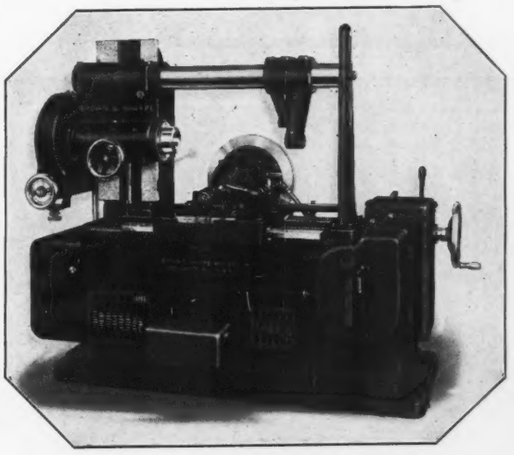

ENGINEERING AND EXPLOSIVES

(*Continued from page 116*)

serves to break the jam and release the ice floes. It has also become an economical agent for the removal of drifts and snow slides from the highways and railroads in the Rocky Mountains and elsewhere.

In mining engineering, of course explosives play an absolutely essential part, as coal and metals could not be mined efficiently without them and rock could not be quarried in sufficient quantities to supply present-day demands.

Dynamite today is being made in strengths to suit all needs. One of the greatest improvements in its manufacture in recent years has been the development of a low freezing formula. Dynamite of this type can now be used without difficulty at very low temperatures, in fact, a recent test made in Minnesota showed that at thirty-five degrees below zero it detonated perfectly.

The explosives industry seems to be keeping pace with the demands of modern engineering practice and each year improvements are made not only in the character and adaptability of explosives but also in the methods of using them in mining operations and construction work.

New Ammonia Catalyst. A new ammonia catalyst has been developed by the Fixed Nitrogen Research Laboratory of the Department of Agriculture which brings about the permanent union of nitrogen and hydrogen and yields various proportions of ammonia according to the particular promoter used in the catalyst. The latter is described as a reduction product of iron oxide containing promoters. The promoters are also classified so that a selection may be made from them that will give any kind of catalyst that may be wanted, depending on operating conditions. For example, a yield of 14 per cent ammonia has been obtained by the use of catalysts, in the making of which 2 per cent of potassium aluminate is used as a promoter. Some promoters will give a greater yield of ammonia and some a lesser yield, but the former have not been practically developed, as it is believed that they cannot be obtained economically. — *Scientific American.*

BOOK REVIEW

Electrical Measuring Instruments and Supply Meters, by D. J. Bolton. E. P. Dutton & Co., New York, 1923. Price $5.00.

The use of measuring instruments and supply meters is very extensive in all branches of engineering and it is necessary for every engineer to have some handy source of information regarding their theory and practical application. In spite of this need, the available data on the subject has been scattered throughout the mass of literature written on the general subject of electrical engineering. And until recently, few attempts have been made to isolate the field of measuring devices and treat them in such a way as to be easily understood by the average non-electrical engineer.

"Electrical Measuring instruments and Supply Meters," is not intended for use by the designer of electrical apparatus. Rather it is a reference book for students and engineers, who occasionally must use measuring instruments and find that to use them intelligently, they must review the theory of their operation. The entire field is covered in such a manner as to be easily intelligible to those who have only a slight knowledge of the fundamentals of mathematics and electricity. One hundred and eighty photographs and line drawings are used to illustrate the various instruments discussed in the text.

One of the most valuable features of the book is the discussion of the uses for which various types of meters are adapted and their probable accuracy. Very often the scale of an instrument can be read more closely than is warranted by the conditions under which the measurement is made. It is important for the engineer to know to what extent he can rely on the data obtained and before the publication of this volume, all such information has been widely scattered.

BUFF Instruments

save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

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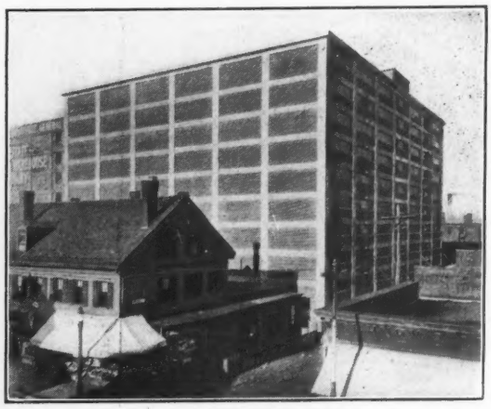

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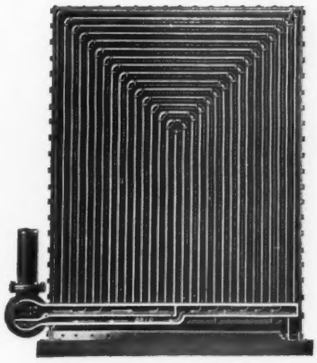
HIDES AND SKINS CAN BE DRIED

Regardless of Weather Conditions



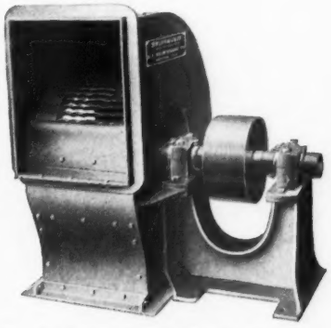
Section of a Sturtevant heater used in the drying systems for maintaining a proper degree of temperature.

WELL-REGULATED production is difficult to obtain when the drying depends on the sunshine and weather conditions. Even under the most favorable climatic conditions, the process is slow. It is, therefore, necessary to keep a stock which represents an important sum of money.

The tests carried on under actual working conditions show that the time that was heretofore necessary for the drying of hides and leathers has been reduced to a third. This important result is obtained through the use of

Sturtevant (TRADE MARK)

DRYING SYSTEMS



The Sturtevant fan used with the drying systems for obtaining a continuous and well regulated circulation.

BY USING THESE SYSTEMS

(1) **Stocks can be reduced and thereby give employment to otherwise idle money.**

(2) **Smaller plant space required than by natural methods.**

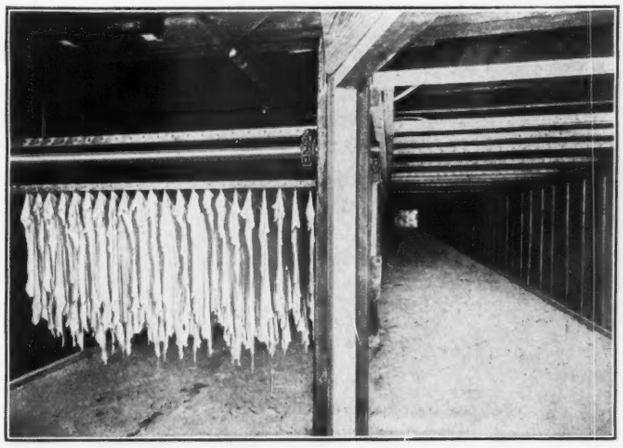
(3) **It is always possible to regulate temperature and humidity.**

(4) **The hides and skins are quickly and thoroughly dried.**

(5) **The quality is not affected.**

Our engineers are always ready to recommend to those interested without any obligation the best drying method for their special requirements.

Ask their help for everything connected with the drying of leathers.



This is one of the typical tunnel arrangements of the Sturtevant Drying Systems. During the drying process the hides keep moving from one end of the tunnel to the other.

B. F. STURTEVANT COMPANY

HYDE PARK BOSTON, MASS.

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Sturtevant PUTS AIR TO WORK

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first-year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

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Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.

What Makes Defense "Air-Tight"?

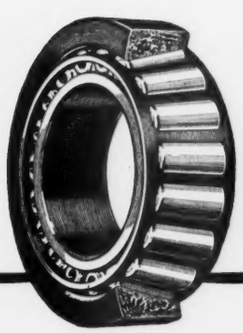
A team with fast, hard-tackling ends and a weak line can no more stop a straight attack, than heavy guards and tackles can break up open plays, when the ends are weak. An "air-tight" defense must stop plays both through the line and from the ends; it must withstand attack from every quarter, just as a good bearing must withstand all loads.

The bearings in the wheels of a motor car, for instance, have a vertical load upon them, represented by the weight of the car. This is termed "radial load". It corresponds in effect to a straight charge by backs upon a football line.

When the car sways, however, or when its course is sharply changed, a part of the weight of the car is thrown sidewise against the bearings in the wheels. This load is called "end thrust". It corresponds in effect to a diagonal attack upon a football line.

In actual operation, a wheel bearing must meet continuously both "radial load" and "end thrust"—must as it were, withstand attack through center, off tackle, or from the ends. Because of its *tapered* principle, a Timken Tapered Roller Bearing withstands, in one bearing, all these loads. It is upon this principle that the unquestioned leadership of Timken Bearings is founded—a leadership extending beyond the automotive field throughout industry generally.

The Timken Roller Bearing Company
CANTON, OHIO



TIMKEN
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ROLLER BEARINGS

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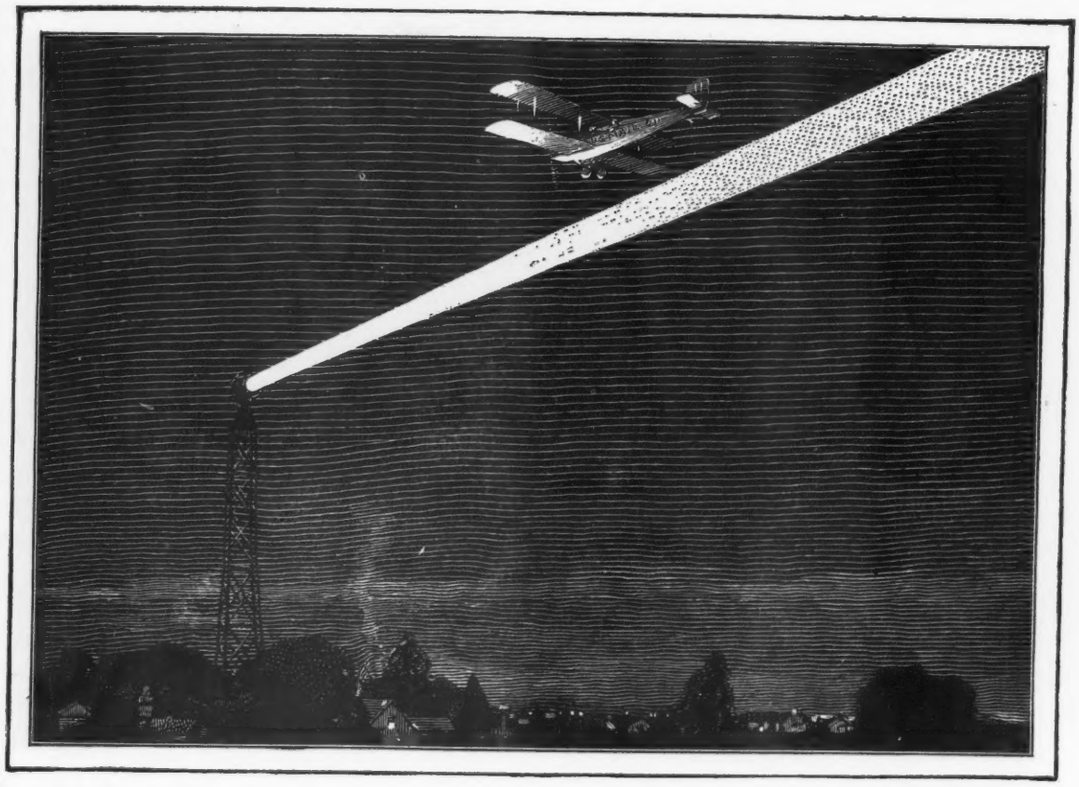

Beacons of the sky

Between Cleveland and Rock Springs, Wyo., along the night route of the air mail service, tall beacons have been placed every twenty-five miles.

Revolving on great steel towers, General Electric searchlights, totaling 1,992,000,000 candle-power, blaze a path of light for the airplane pilot.

What the lighthouse is to the ocean navigator, these beacons are to the conquerors of the air.

This achievement has been made possible by engineers of the Illuminating Engineering Laboratories of the General Electric Company, working with officials of the Post Office Department. A startling achievement now will be a commonplace of life in the *new* America which you will inherit.

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